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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION

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Preface

This first APHIS 81 issue produced by the Biological Assessment Support Staff (BASS) continues, beginning with number 12, the series of Pests Not Known To Occur in the United States or of Limited Distribution (PNKTO) articles. This series is intended to give facts about exotic pests as an aid to assigning priorities, in detection, control, and containment strategies and as a guide to available literature. The first 11 were published in the "Cooperative Plant Pest Report" (CPPR) which ceased publication in October 1980. These first 11 will be revised and reissued in this format at a later date.

This series had as its forerunner the "Insects Not Known To Occur in the United States" (INKTO) series published in the "Cooperative Economic Insect Report" (CEIR). There were 198 INKTO articles issued before the name of the CEIR was changed and the scope enlarged to include all classes of plant pests. Some of these insect species will be included in the PNKTO series as they are revised according to need.

The scope and range of species treated in the PNKTO series were also widened and the concept of "Limited Distribution" added to allow the inclusion of articles about pests that became established and subsequently eradicated to be included without concern for whether or not the species was actually exotic. Also included in this concept are pests that are so limited in distribution that they may be treated as though they were exotic.

Included in this issue are the first two groups of pests, 12 through 17 and 18 through 23. Articles will be routinely arranged to allow for as much complementing of information within the group as is practical from the range of current pest articles.

PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 12: CROTON WHITEFLY

Prepared by S. Nakahara, USDA, APHIS, PPQ,
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Order: Family — Homoptera: Aleyrodidae

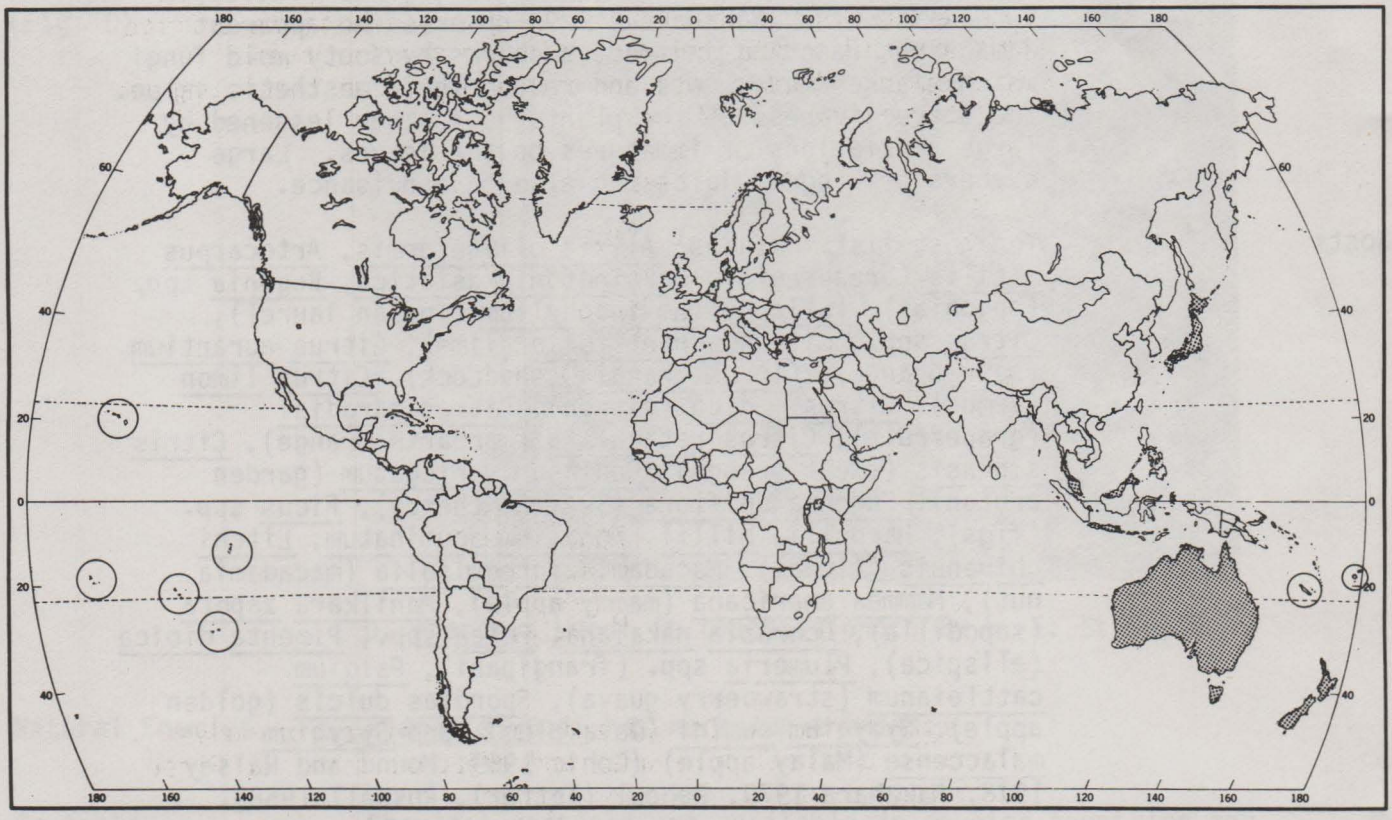
Pest — CROTON WHITEFLY
Orchamoplatus mammaeferus (Quaintance and Baker)

Economic Importance — *Orchamoplatus mammaeferus* is one of the main pests of orange in Rarotonga, Cook Islands (Dumbleton 1954), and sometimes is a pest in New Caledonia (Fabres (letter)). In Hawaii, L. M. Nakahara (1979) observed no apparent damage but reported indirect problems by sooty mold fungi which blacken the plants and reduce their aesthetic value. The attractiveness of the plants is further lessened by large populations of immatures on the leaves. Large numbers of winged adults can also be a nuisance.

Hosts — The host list includes: *Alyxia olivaeformis*, *Artocarpus altilis* (breadfruit), *Barringtonia asiatica*, *Begonia* spp. (begonias), *Callophyllum inophyllum* (Indian laurel), *Citrus* spp., *Citrus aurantifolia* (lime), *Citrus aurantium* (sour orange), *Citrus grandis* (shaddock), *Citrus limon* (lemon), *Citrus medica* (citron), *Citrus paradisi* (grapefruit), *Citrus reticulata* (mandarin orange), *Citris sinensis* (sweet orange), *Codiaeum variegatum* (garden croton), *Eugenia uniflora* (Surinam cherry), *Ficus* spp. (figs), *Harpullia hillii*, *Honalium acuminatum*, *Litchi chinensis* (litchi), *Macadamia integrifolia* (macadamia nut), *Mammea americana* (mammy apple), *Manilkara zapota* (sapodilla), *Ochrusia nakaiana*, *Pelea* spp., *Pimenta dioica* (allspice), *Plumeria* spp. (frangipani), *Psidium cattleianum* (strawberry guava), *Spondias dulcis* (golden apple), *Syzygium cumini* (Java plum), and *Syzygium malaccense* (Malay apple) (Cohic 1959, Mound and Halsey 1978, Nakahara 1979, Reboul (letter), Russell 1958).

General Distribution — Hawaii (Maui and Oahu), Australia, Cook Islands (Aitutaki, Rarotonga), Fiji, Indonesia (Java), Japan, Malaysia, Marquesas Islands, New Caledonia, New Zealand, Samoa, Singapore, Society Islands (Bora Bora, Moorea, and Tahiti), and Tuamotu Islands (Makatea) (Cohic 1959, Dumbleton 1954, Russell 1958).

In recent years, O. mammaeferus has been intercepted by agricultural quarantine officers principally at Honolulu, Hawaii, and California ports. It was found on Citrus and Codiaeum leaves from American Samoa, Australia, Cook Islands, Hawaii, and Tahiti. This species was first detected in Honolulu, Hawaii, in 1976 on Codiaeum, and subsequently has been found on other host plants and on the island of Maui (Nakahara 1980).



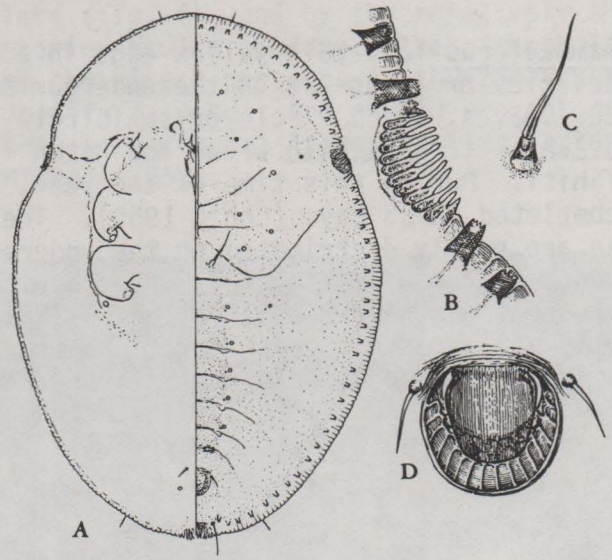
Orchamoplatus mammaeferus distribution map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Characters

Wax secretions colorless or yellowish, transparent, glassy, and completely covering larvae and pupae. Often waxes of individuals coalesce.

PUPAE (figs. A-D) - Oval, flat, and widest across metathorax. Pupae about 0.75-1.0 mm long, 0.5-0.7 mm wide; colorless or yellowish, and membranous. Tracheal pore area with teeth differentiated sharply from rest of weakly crenulated margin. Thoracic tracheal pore area not expanded into plate, and teeth not recessed into submargin. Single row of 40-47 submarginal glands around body. Cephalic setae absent from dorsum; pair of submedian setae on abdominal segment 1; caudal setae 80-100 microns (mu) long, and bases separated by about twice the length of submarginal gland. Vasiform orifice and operculum subcircular. Lingula shorter than operculum. Ventral minute spines less than 5 mu long, a sparse (Russell 1958).

(Figs. A-D)



O. mammaeferus: A. Dorsal and ventral halves of body; B. Thoracic tracheal pore area and adjacent derm; C. First abdominal seta; D. Vasiform orifice

ADULTS - Tiny, about 2 mm long, and covered with white, powdery wax.

Characteristic Damage

This whitefly infests the leaves in large numbers and lessens plant vigor by sucking sap. At times, the wax secretion of this pest virtually covers the lower surfaces of the leaves. Copius amounts of honeydew secreted by the immatures of this species coat the leaves, stems, and fruits. Sooty mold fungi that develop on this secretion interfere with photosynthesis and reduce the attractiveness of ornamental plants. Fruits coated with sooty mold fungi are unmarketable or reduced in value.

Detection Notes

1. Examine plants blackened with sooty mold fungi, with droplets of honeydew secretion, or with tiny, white winged adults. In heavy infestations, a swarm of adults will rise from the plants when the plants are shaken.

2. Examine the undersides of the leaves for characteristic glassy, transparent wax secretions, and pale or yellowish larvae and pupae.

3. Collect infested leaves and submit for identification. Do not submit adults without associated pupae because only the pupae of whiteflies can be determined to species.

Biology

O. mammaeferus lays pale yellow eggs in a circle, semicircle, or in an arc on the undersurfaces of young and tender leaves. Each circle or semicircle contains 30-60 eggs, which turn reddish brown and hatch in 8 days in May in Tahiti. During this time of the year, the life cycle is completed in 35 days (Cohic 1955). The oval larvae and pupae are evenly distributed on the undersurfaces of the leaves, and each individual is covered with a glassy, transparent wax secretion (figs. E-F) (Nakahara 1979) that usually coalesces with wax secretions produced by adjacent individuals. According to Cohic (1955), Codiaeum is the reservoir of this whitefly in Tahiti and elimination of Codiaeum bordering Citrus orchards will be useful.

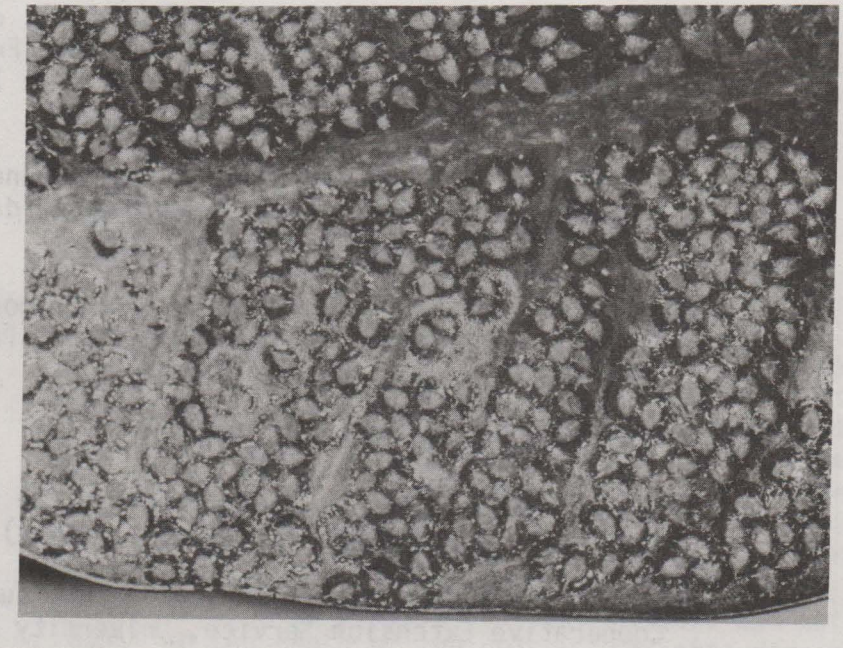
Natural Enemies

In Hawaii an Aphelinidae parasitoid, Encarsia sp., was found once. Two Coccinellidae predators, Serangium maculigerum Blackburn and Orcus chalybeus (Boisduval), were reported feeding on immatures. However, none of these species were effective as control agents. (Nakahara, personal communication).

Acknowledgment

The preparer thanks S. Higa and L. M. Nakahara, Hawaii Department of Agriculture, Honolulu, for the information and photographs and L. M. Russell, Systematic Entomology Laboratory, Beltsville, MD, for permission to use the illustrations.

(Fig. E)



O. mammaeferus: Pupae on undersurface of Codiaeum leaf (Courtesy of L. M. Nakahara)

(Fig. F)

O. mammaeferus: Pupae enlarged (Courtesy of L. M. Nakahara)

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 13: AUSTRALIAN CITRUS WHITEFLY

Prepared by S. Nakahara, USDA, APHIS, PPQ,
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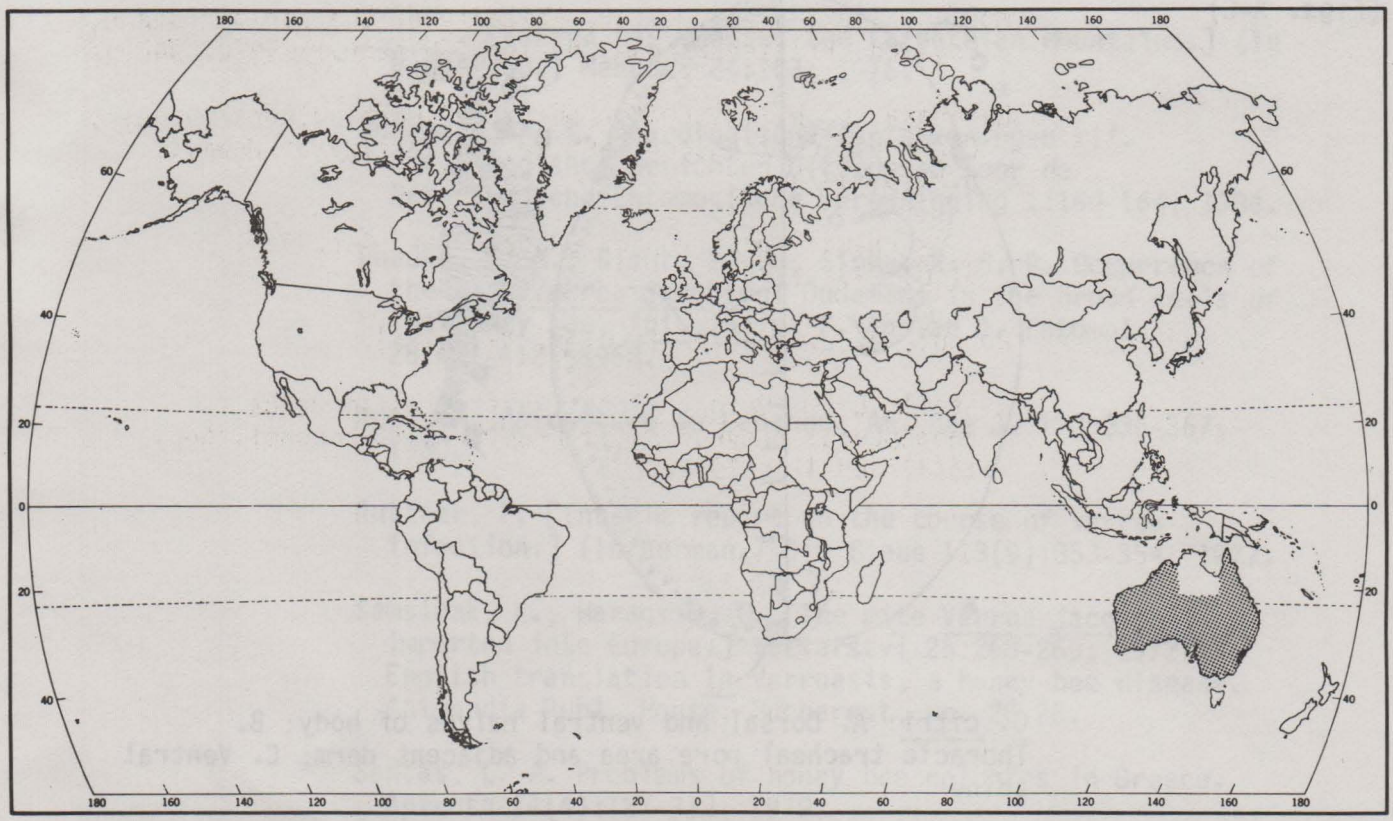
Order: Family — Homoptera: Aleyrodidae

Pest — AUSTRALIAN CITRUS WHITEFLY
Orchamoplatus citri (Takahashi)

Economic Importance — According to Jenkins and Shedley (1953), *Orchamoplatus citri* is a pest of lemons and other *Citrus* spp. in Western Australia. The sooty mold fungi which coat the fruits cause the most concern.

Hosts — *O. citri* is known only from *Citrus* spp. (Russell 1958).



Orchamoplatus citri map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

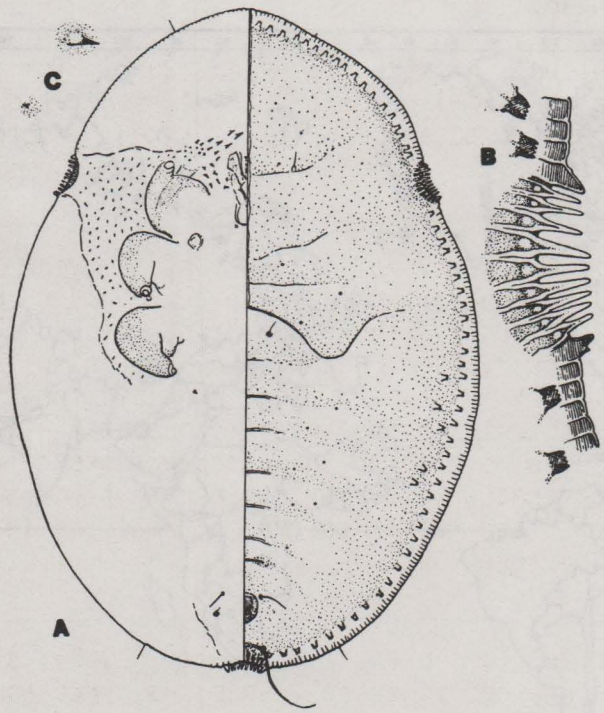
General Distribution — *O. citri* is known only from Australia: New South Wales, Victoria, Western Australia (Jenkins and Shedley 1953), South Australia, and Queensland (Mound and Halsey 1978).

Characters

This species is similar to O. mammaeferus (PNKTO #12) except as follows:

PUPAE (figs. A-C) - Not yellowish, ovoid, and widest across abdominal segments 1 and 2. Additional row of 4-6 submarginal glands mesad of submarginal row on abdominal segments 1-4 on each side. Cephalic setae present on dorsum; caudal setae 160-200 mu long, and bases separated by 4-5 times length of submarginal gland. Numerous ventral minute spines, 2-25 mu long, on cephalothorax; few outside posterior legs extending cephalad along tracheal fold in broad band to margin, present between anterior leg and mouthparts (Russell 1958).

(Figs. A-C)



O. citri: A. Dorsal and ventral halves of body; B. Thoracic tracheal pore area and adjacent derm; C. Ventral spine

Characteristic Damage

This whitefly infests the leaves in large numbers and lessens plant vigor by sucking sap. At times, the wax secretion of this pest virtually covers the lower surfaces of the leaves. Copius amounts of honeydew secreted by the immatures of this species coat the leaves,

stems, and fruits. Sooty mold fungi that develop on this secretion interfere with photosynthesis and reduce the attractiveness of ornamental plants. Fruits coated with sooty mold fungi are unmarketable or reduced in value.

Detection Notes

1. Examine plants blackened with sooty mold fungi, with droplets of honeydew secretion, or with tiny, white winged adults. In heavy infestations, a swarm of adults will rise from the plants when the plants are shaken.

2. Examine the undersides of the leaves for characteristic glassy, transparent wax secretions and pale larvae and pupae.

3. Collect infested leaves and submit for identification. Do not submit adults without associated pupae because only the pupae of whiteflies can be determined to species.

Biology

O. citri has several generations per year in Western Australia and all stages can be found on the plants simultaneously. The populations are usually greatest when succulent, young growth is present in spring and autumn and lowest in winter. Eggs are laid in a horseshoe shape or semicircle on the undersides of the leaves. The larvae and pupae develop on the undersurfaces of the leaves and are covered with glassy, transparent wax secretions. The adults often gather on young shoots and leaves (Jenkins and Shedley 1953).

Natural Enemies

According to Jenkins and Shedley (1953), slight control was achieved by several parasites, predators, and a beetle, Clambus sp.

Acknowledgment

The preparer thanks L. M. Russell, Systematic Entomology Laboratory, Beltsville, MD, for permission to use the illustrations.

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 14: ORANGE SPINY WHITEFLY

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 626, Hyattsville, MD 20782

Order: Family

Homoptera: Aleyrodidae

Pest

ORANGE SPINY WHITEFLY
Aleurocanthus spiniferus (Quaintance)

Economic Importance

A. spiniferus has been called the most destructive aleyrodid infesting citrus in tropical Asia. It has been rated as the seventh most important citrus insect, the most important of more than four citrus-feeding aleyrodid species in Japan. An outbreak in the Kyushu area was devastating until brought under control in the early 1920's by the parasite Prospaltella smithi Silvestri, a eulophid wasp. A. spiniferus had become the most serious pest on the island of Guam, but by 1953 introduced parasites had effectively controlled the outbreak. Trees heavily infested with this whitefly lose vitality and continued heavy infestations eventually lead to tree mortality (U.S. Department of Agriculture 1959).

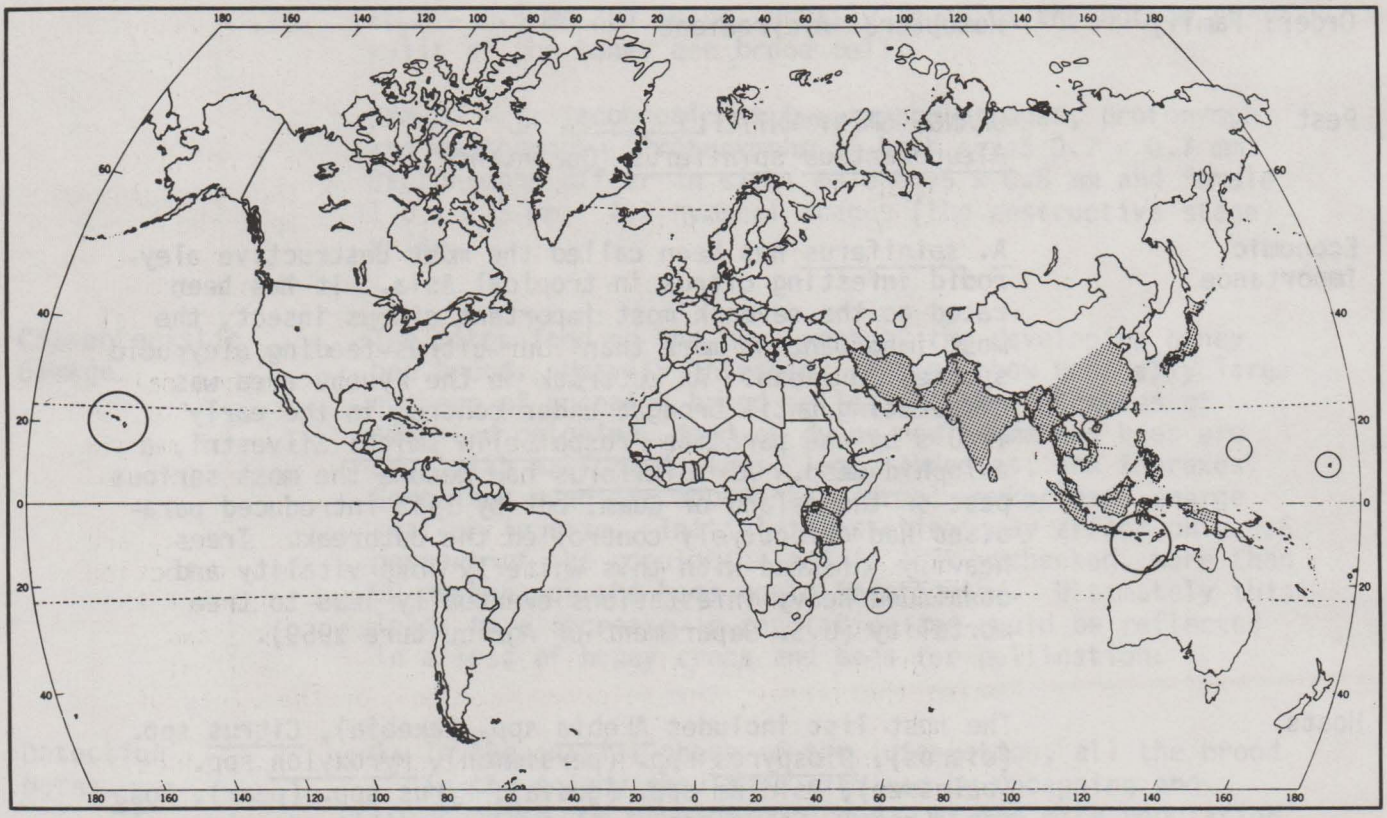
Hosts

The host list includes Akebia spp. (akebia), Citrus spp. (citrus), Diospyros spp. (persimmon), Myroxylon spp. (balmtree), Psidium spp. (guava), Pyrus spp. (pear), Rosa spp. (rose), Salix spp. (willow), and Vitis spp. (grape) (Mau et al. 1974).

General Distribution

A. spiniferus occurs in Asia: China, Hong Kong, India, Indonesia, Iran, Japan, Macao, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam; in Africa: Kenya, Mauritius, and Tanzania; and Pacific Islands: Guam and Truk (Caroline Islands) (Commonwealth Institute of Entomology 1976). It has been recorded by several authors from Jamaica, but apparently these records were based on misidentifications, according to L. M. Russell of the U.S. National Museum of Natural History (Weems 1962).

In the United States, this species is present in Guam (see above) and Hawaii, first detected in 1974 on Oahu (Mau et al. 1974).



Aleurocanthus spiniferus map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Characters

ADULTS - Female 1.33 mm and male 0.96 mm long, orange yellow shaded with brownish purple and sprinkled with white waxy powder, eyes reddish, antennae and legs yellowish, thorax yellowish with purple markings, forewings length 1.29 mm and width 0.6 mm, color pattern of wings variable (fig. A). The male genitalia is useful in distinguishing among similar species (fig. B).

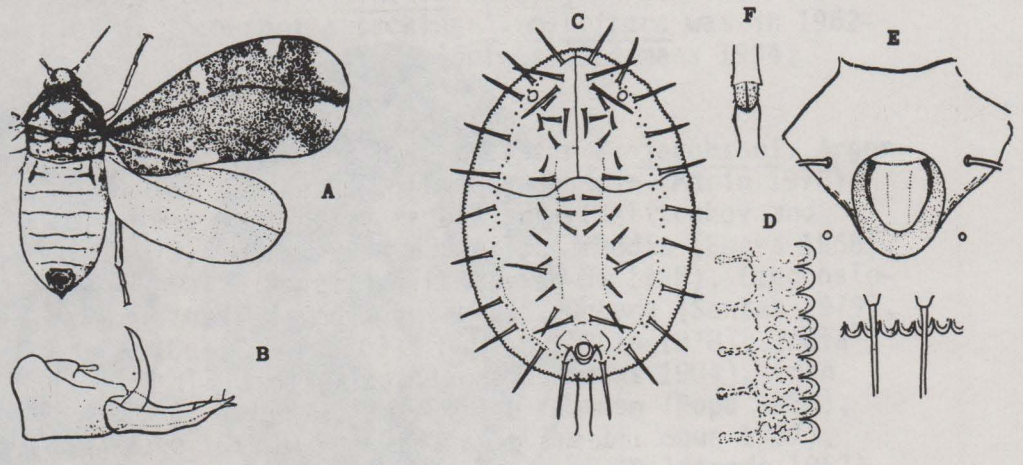
EGGS - On short stalks that hold them upright on the leaves. Creamy yellowish, 0.2 mm long by 0.1 mm wide, curved and marked with minute polygonal areas.

LARVAE - First instar 0.315 by 0.153 mm, second instar 0.4 by 0.3 mm, and third instar 0.66 by 0.525 mm. Body elliptical brownish to black, with short cottony fringe of wax all around. Spines stout and numerous.

PUPAE - Females larger than males, size of case 1.23 by 0.88 mm, length about 1 mm, convex, oval, black, (fig. G) with a marginal band of white waxy secretion. Dorsum arched and median area prominent especially at the vasiform orifice which is elevated subcordate tending to circular and is almost entirely filled with the operculum (fig. E). Pupa case with 16-26 spines that form the submarginal ring (figs. C and H), submarginal spines not long and prominent, average 0.22 mm, extend beyond the margin of case (figs. C, D, and H). There is a subdorsal row of shorter spines and a submedian row of still shorter ones. Caudal margin with pair of setae and another pair situated near cephalic margin of vasiform orifice (fig. E). Margin is strongly dentate (fig. D). Teeth of margin not large or acute, moderate in size, 12 teeth per 0.1 mm.

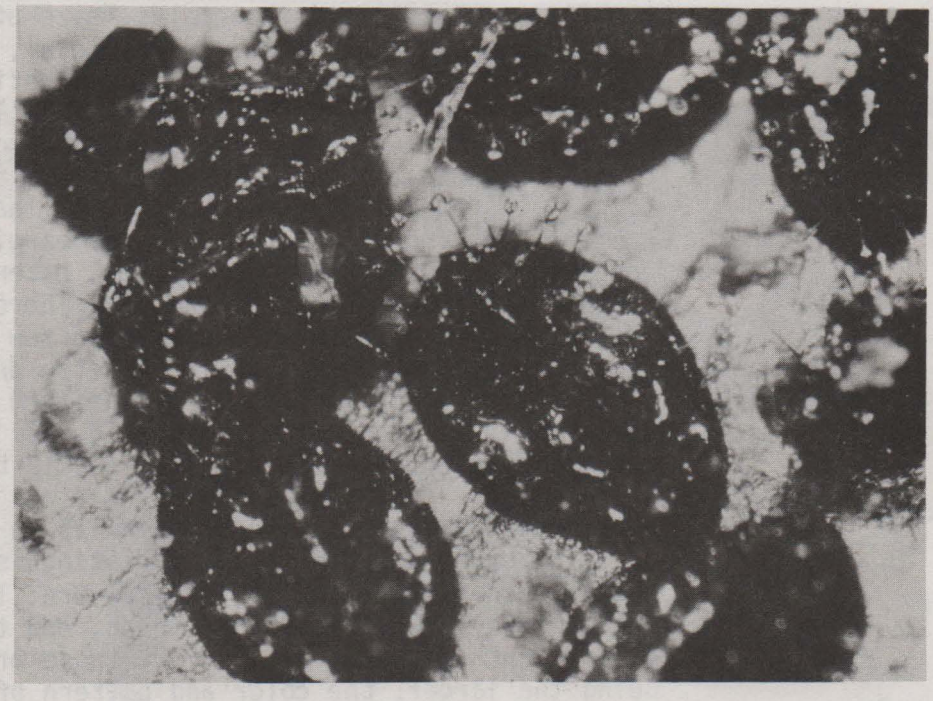
Aleurocanthus woglumi (see article #15 in this series) and A. spiniferus are difficult to distinguish (see detection notes). In summary the differences are: The pupae of the latter have narrower marginal teeth, and the size and arrangement of the spines differ, those of A. woglumi being the larger; the color and pattern of the wings of the adults also are distinctive (Weems 1974, U.S. Department of Agriculture 1959, Kuwana 1928, Quaintance and Baker 1917).

(Figs. A, B, C, D, E, F)



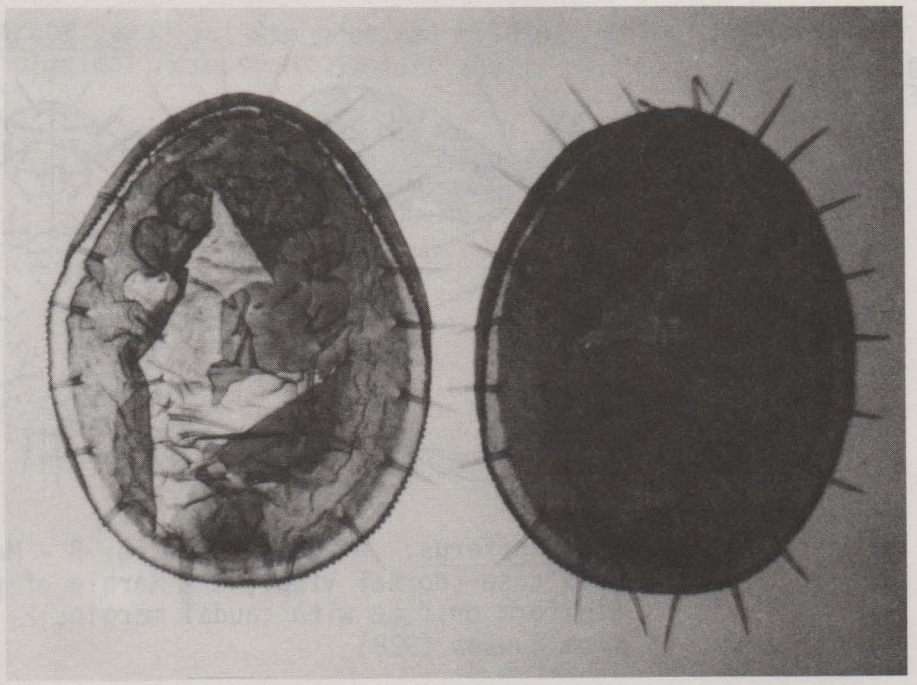
A. spiniferus: A - Adult female; B - Male genitalia; C - Pupa case (dorsal view); D - Margin of pupa case; E - Vasiform orifice with caudal margin; F - Lingula (figs. from Kuwana 1928)

(Fig. G)



Pupae of A. spiniferus

(Fig. H)



Slide mount of A. spiniferus pupae showing pattern of marginal teeth and spines

Characteristic Damage

This species excretes honeydew that falls on the leaves, causing the growth of a sooty mold which interferes with the normal function of the leaves, reducing respiration and photosynthesis. During heavy infestations, the sooty mold also occurs on the fruit, lowering its quality. Continual heavy infestation leads to tree mortality.

Detection Notes

1. Inspect for spiral egg masses and larvae on underside of leaves. The larvae of this species resemble A. woglumi but the arrangement of the spines differ. A. spiniferus is indistinguishable from A. woglumi in the field.

2. Detection can be done any time of the year, but adults would not be found during the winter.

3. Watch for honeydew, sooty mold on leaves and fruit, and ant trails.

4. The colorful adult may be found periodically, assembled on tender terminal growth (Paddock 1976, personal communication)

Natural Enemies

Listed below are the various natural enemies which have been found to attack A. spiniferus throughout subtropical and tropical Asia (Clausen 1934).

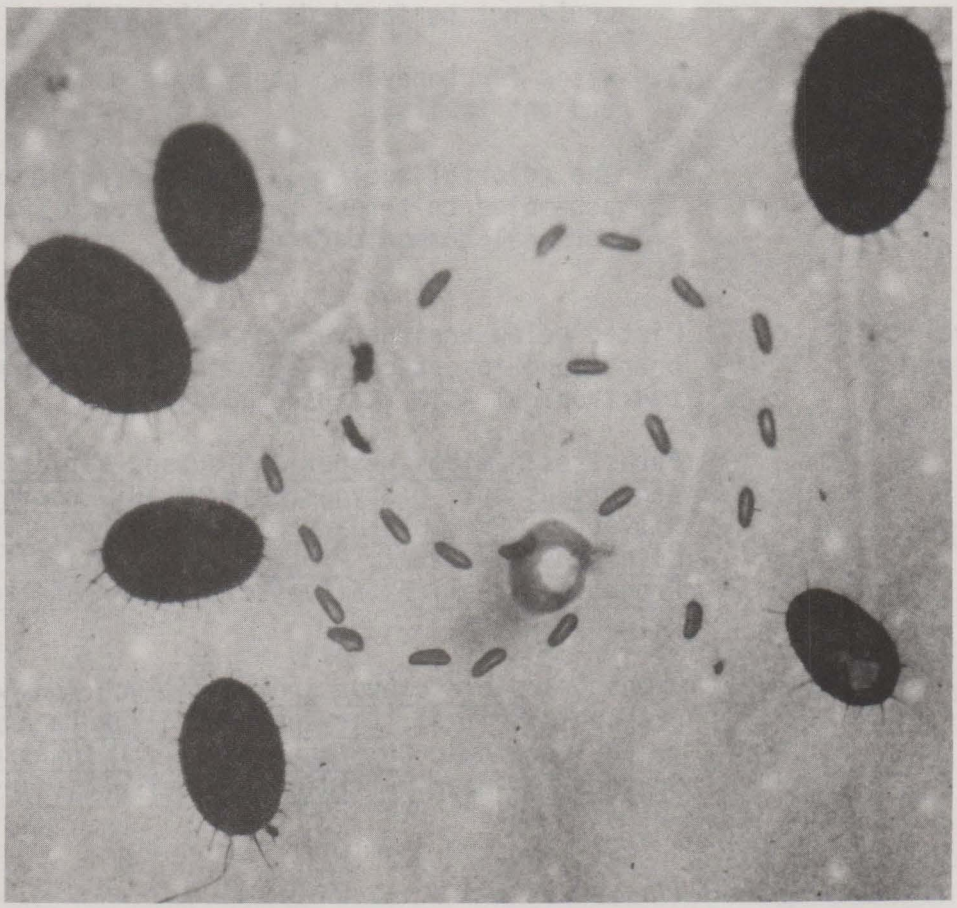
Parasites: Amitus hesperidum subsp. variipes Silvestri, and Amitus sp., platygasterid wasps; Encarsia merceti Silvestri, Eretmocerus serius Silvestri, Prospaltella divergens Silvestri, Prospaltella ishii Silvestri, Prospaltella smithi Silvestri, and Prospaltella sp., eulophid wasps.

Predators: Acletoxenus indica Malloch and Acletoxenus sp., drosophilid flies; Chrysopa fulvolineata and Chrysopa sp., green lacewings; Cryptognatha sp., Delphastus sp., and Scymnus sp. near pallidicollis Mulsant, lady beetles.

Biology

A. spiniferus deposits as few as 12-13 eggs in a spiral pattern on the underside of leaves (fig. I). Incubation varies, depending on temperature, and averages 22 days in May, 7 in July, 11 from August to September, and 15 from September to October. There are four broods per year in Japan. The insect overwinters in the third larval stage, reaching the pupal stage about the middle of March. The adult emerges from the middle to the end of April, second brood adults emerge the last part of June, the third brood the first part of August, and the fourth brood during the last part of September. Adults are active on fine days but are quiet during cloudy or rainy weather. They prefer the undersides of new leaves (U.S. Department of Agriculture 1959).

(Fig. I)



Aleurocanthus spiniferus: Spiral pattern of eggs

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 15: CITRUS BLACKFLY

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 626, Hyattsville, MD 20782

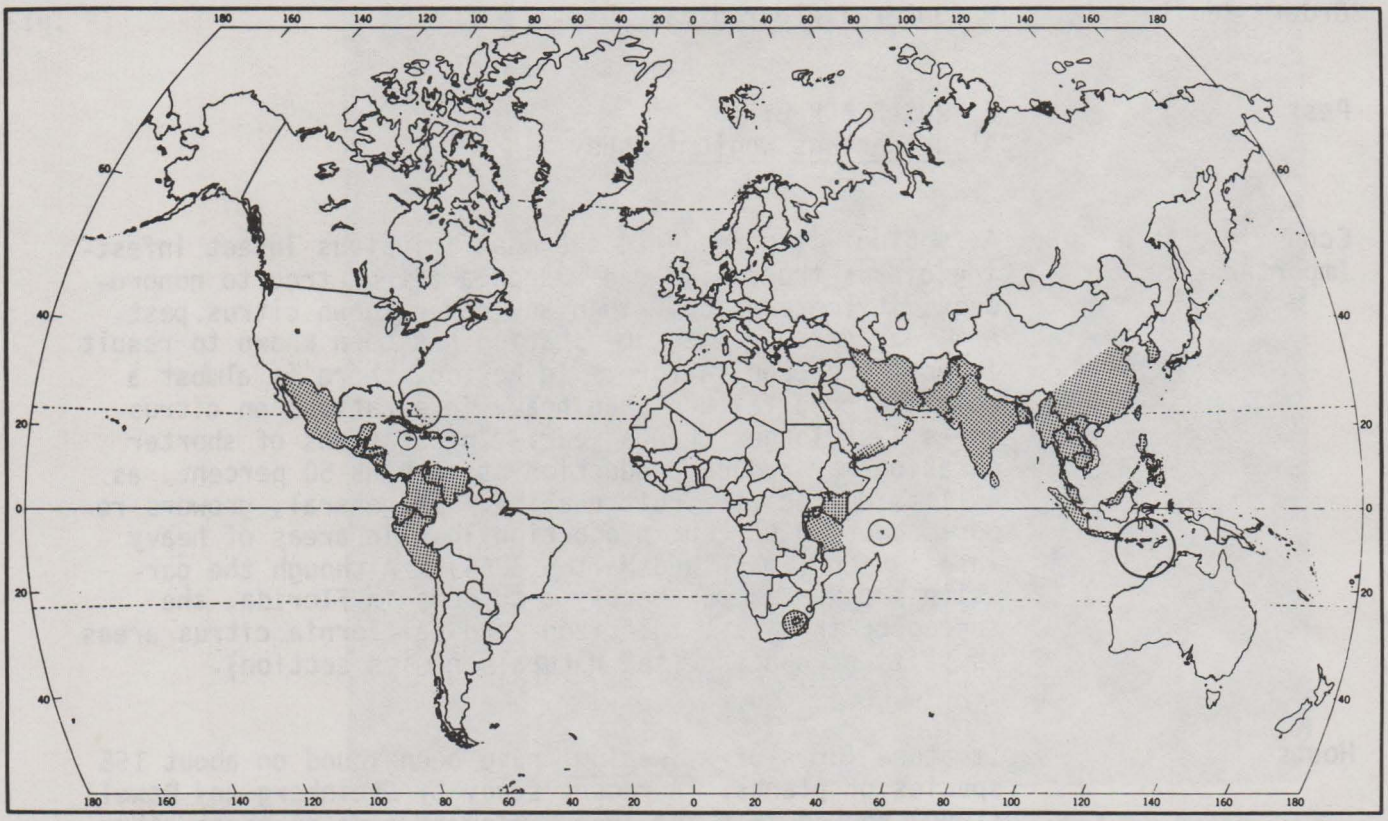
Order: Family — Homoptera: Aleyrodidae

Pest — CITRUS BLACKFLY
Aleurocanthus woglumi Ashby

Economic Importance — *A. woglumi* is considered the most injurious insect infesting citrus trees. It can reduce a citrus tree to nonproductivity more quickly than any other known citrus pest. A 2-year uncontrolled infestation has been known to result in complete crop failure. In Mexico, there is almost a complete crop failure when heavy infestations on citrus trees last longer than a year. Infestations of shorter duration may reduce production as much as 50 percent, as well as depreciate fruit quality. In general, growers report about 80 percent production loss in areas of heavy infestation (Smith and Maltby 1964). Although the parasite program is apparently a success in Florida, the spread of this pest to Arizona and California citrus areas is still of concern (see natural enemies section).

Hosts — Immature forms of *A. woglumi* have been found on about 155 species of plants. A recent study by Steinberg and Dowell (1980) showed that the infestation of some of these other hosts may depend on the presence of nearby infested citrus. The most important hosts of the rutaceous plants are *Atalantia spinosa* (atalantia), *Citrus aurantiifolia* (lime), *C. aurantium* (sour orange), *C. grandis* (shaddock), *C. limon* (lemon), *C. medica* (citron), *C. reticulata* (mandarin and tangerine), *C. paradisi* (grapefruit), *C. sinensis* (sweet orange), *Fortunella* sp. (kumquat), *Severinia buxifolia* (Chinese box orange), *Swinglea glutinosa* (tabog), and *Triphasia trifolia* (limeberry); and the nonrutaceous plants: *Annona cherimola* (cherimoya), *Coffea arabica* (coffee), *Cydonia oblonga* (quince), *Diospyros* sp. (persimmon), *D. ebenum* (ebony), *D. kaki* (Japanese persimmon), *Myrtus communis* (myrtle), and *Pyrus communis* (pear). In the United States, citrus and mango were considered preferred hosts during the Key West, Florida, (see distribution) infestation (Shaw 1950).

General Distribution — *A. woglumi*, a native of India, occurs in Asia: Bangladesh Burma, Cambodia, China, Indonesia (Java and Sumatra), Iran, Korea, Laos, Malaysia, Oman, Pakistan, Philippines, South Yemen, Sri Lanka, Taiwan, Thailand, and Vietnam;



Aleurocanthus woglumi map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

and in Africa: Kenya, Seychelles, South Africa (first recorded in 1959), and Tanzania. It was first discovered in the New World in Jamaica in 1913, and the infestation has spread to the West Indies: The Bahamas, Cuba, and Haiti; Mexico (first recorded in 1935); Central America: Costa Rica, El Salvador, Guatemala, Nicaragua, and Panama; and South America: Colombia, Ecuador, Peru, and Venezuela (first recorded in 1965) (Commonwealth Institute of Entomology 1976).

In the United States, A. woglumi was found and eradicated in Key West, Florida, in 1934-37 and in Brownsville, Texas, in 1955-56 (Smith and Maltby 1964). Reintroduction and establishment occurred in Florida in 1976 and Texas in 1971 (U.S. Department of Agriculture 1976 and 1971).

Characters

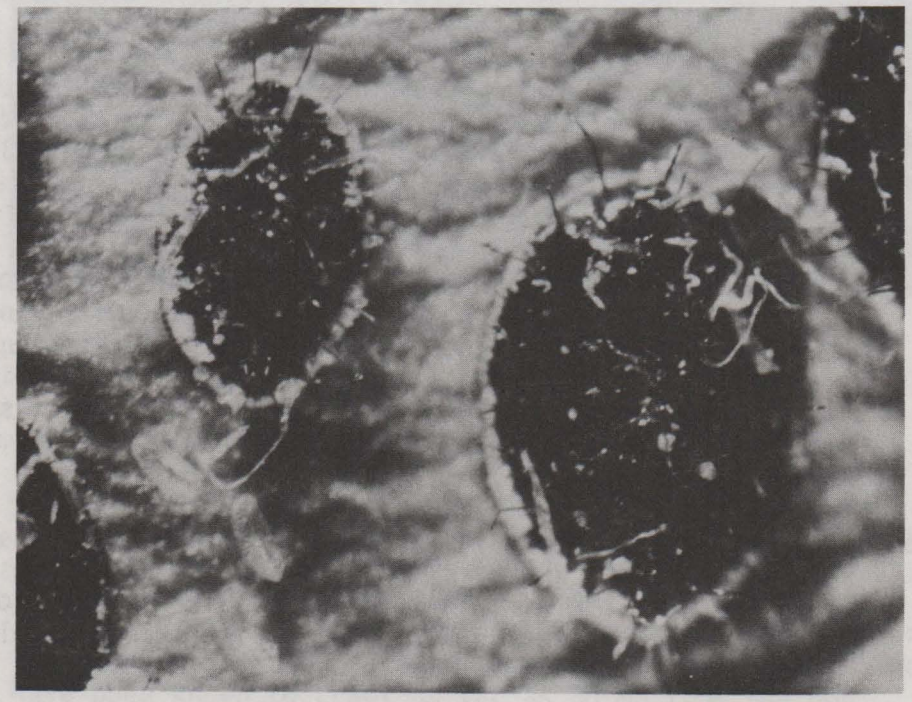
ADULTS - Female 1.66 mm and male 1.33 mm long, head and thorax brick red, frontal head pale yellow, eyes reddish brown, antennae and legs whitish, forewings 1.268 mm long and 0.76 mm wide at the widest part, slate blue wings, colorless spots on wings form what appears as white band across middle of dorsum when at rest.

EGGS - Creamy whitish when first laid, become black in 8-10 days, oblong with round ends.

LARVAE - Length and width vary from 0.300 by 0.150 mm (first instar) to 0.870 by 0.740 mm (third instar), convex, body shiny black and spiny with hemispherical dull green spot on anterior part of abdomen.

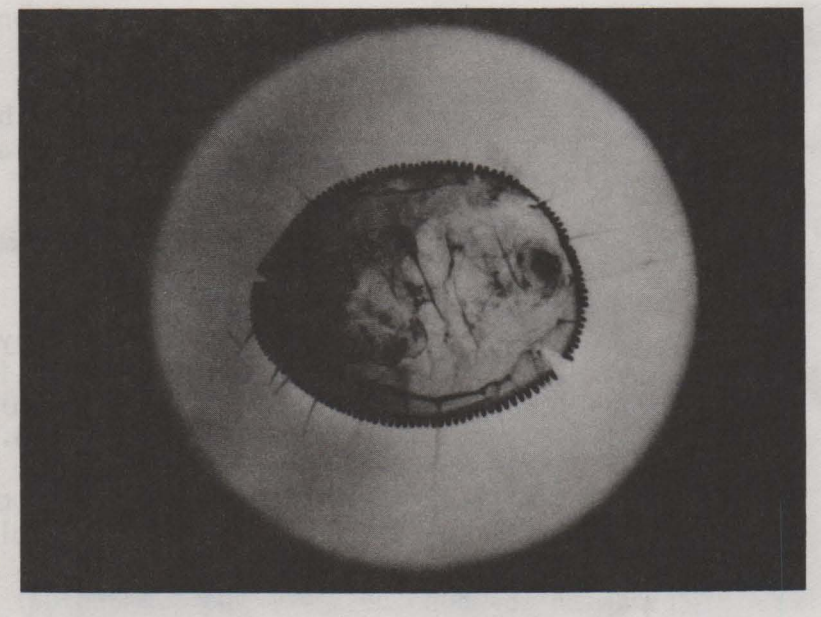
PUPAE - Females larger than males, size of case 1.4 by 0.89 mm, length about 1 mm, convex, oval, black, with a marginal band of white waxy secretion (fig. A). Pupa case with 16-26 spines form the submarginal ring, submarginal spines long and prominent, extend beyond the margin of case. Teeth of margin very large and rounded (fig. B), 6 or 7 teeth per 0.1 mm (Quaintance and Baker 1917, Weems 1962).

(Fig. A)



A. woglumi: Pupa with marginal band of white waxy secretion

(Fig. B)



A. woglumi: Slide mount showing marginal teeth, submarginal spines

A. woglumi and Aleurocanthus spiniferus (see article #14 in this series) are difficult to distinguish (see detection notes). In summary the differences are: The pupae of the latter have narrower marginal teeth, and the size and arrangement of the spines differ, those of A. woglumi being the larger; the color and pattern of the wings of the adults also are distinctive (Weems 1974, U.S. Department of Agriculture 1959, Kuwana 1928, Quaintance and Baker 1917).

Characteristic Damage

This species excretes honeydew that falls on the leaves, causing the growth of a sooty mold which interferes with the normal function of the leaves, reducing respiration and photosynthesis. During heavy infestations, the sooty mold also occurs on the fruit, lowering its quality. Continual heavy infestation leads to tree mortality.

Detection Notes

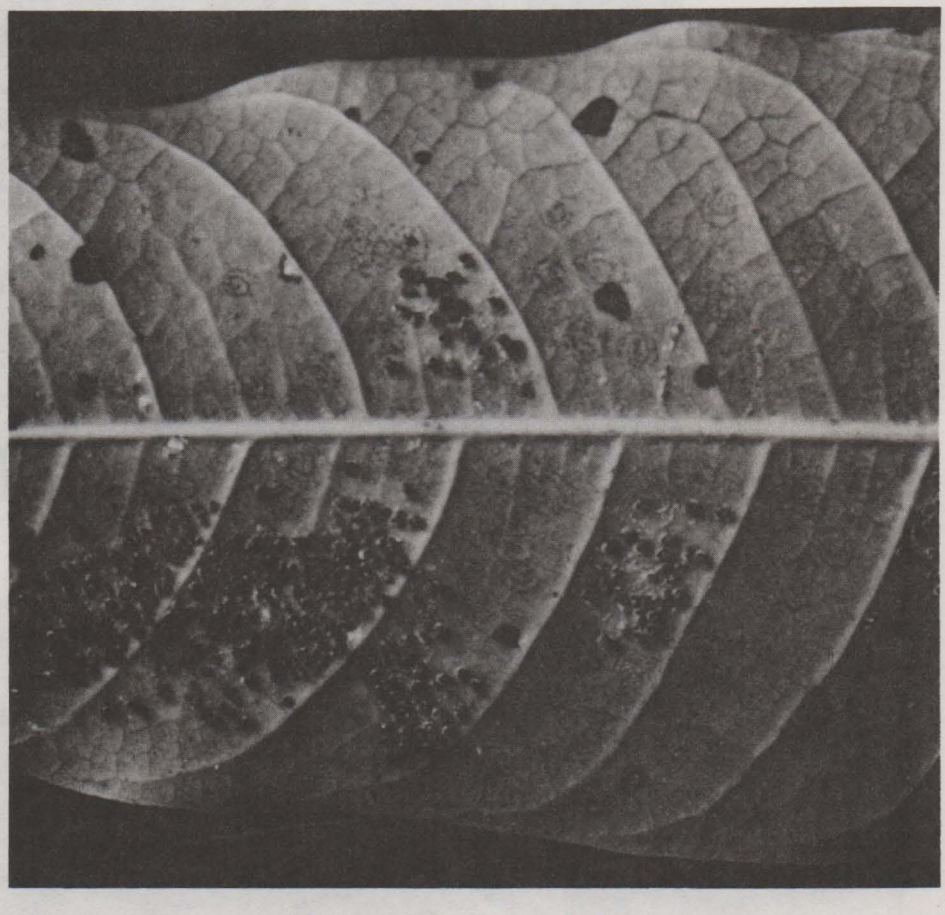
1. Inspect for spiral egg masses and larvae on underside of leaves (fig. C). The larvae of this species resemble A. spiniferus but the arrangement of the spines differ. A. woglumi is indistinguishable from A. spiniferus in the field.

2. Detection can be done any time of the year, but adults would not be found during the winter.

3. Watch for honeydew, sooty mold on leaves and fruit, and ant trails.

4. The dark, smoky-colored adult may be found periodically, assembled on tender terminal growth (Allen 1971, personal communication).

(Fig. C)

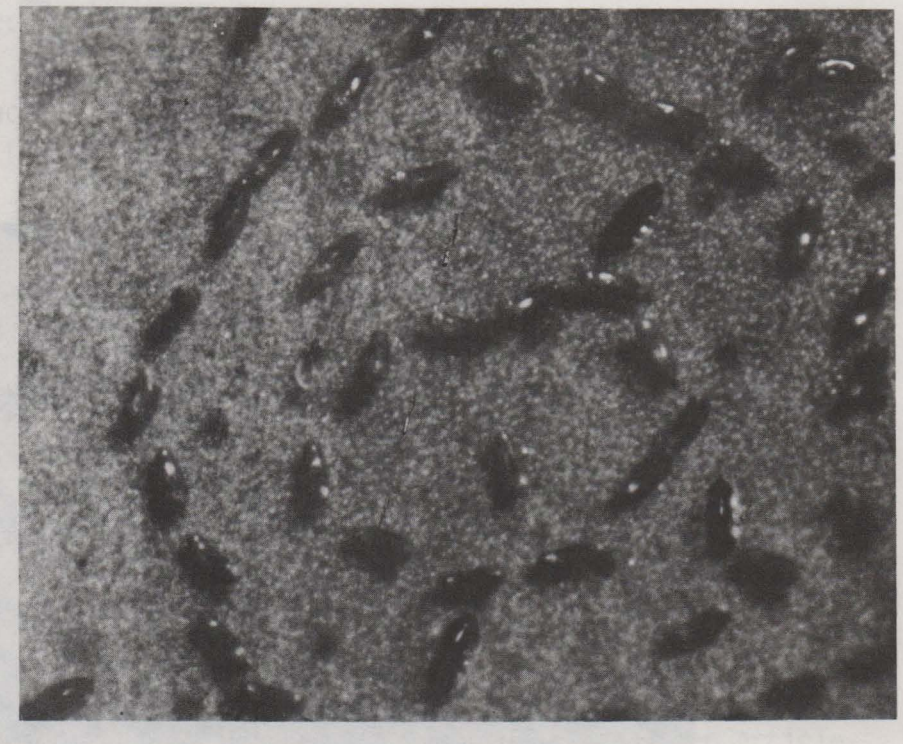


A. woglumi: Egg masses and larvae on underside of leaf

Biology

Eggs are laid on the underside of leaves; about 35-50 eggs per spiral or mass (fig. D). Females lay up to 100 eggs or more during their life span of about 10 days (fig. E). The eggs are attached to the leaf by a short pedicel near the posterior end of the egg. They hatch in about 15 days (7-25 depending on temperature). The temperature limits are -5° and 45°C. The first instar larvae are mobile for 3-5 hours before selecting a permanent feeding site. They have been known to crawl as far as 38 mm from the egg spiral, which is more than enough to spread to other touching plants.

(Fig. D)



A. woglumi: Eggs per spiral

(Fig. E)

A. woglumi: Adult female depositing eggs on host leaf

In a trapping study, Meyerdirk et al. (1979) found that A. woglumi has a diurnal flight pattern stimulated by dawn. Males dominated the morning flights, females the afternoon flights. The optimal height for traps in number caught was 1.5 m in a tree canopy of 3-4 m.

The first larval stage lasts 8-17 days, the second lasts 7-16 days, and the third lasts 7-22 days. The pupal stage lasts 21-45 days (Smith and Maltby 1964). There are 2-6 generations per year, depending on the climate. Development is more rapid on succulent foliage under conditions of almost constant humidity. In Mexico, the life cycle is completed in 2-4 months (Cherry 1979, Dowell et al. 1978).

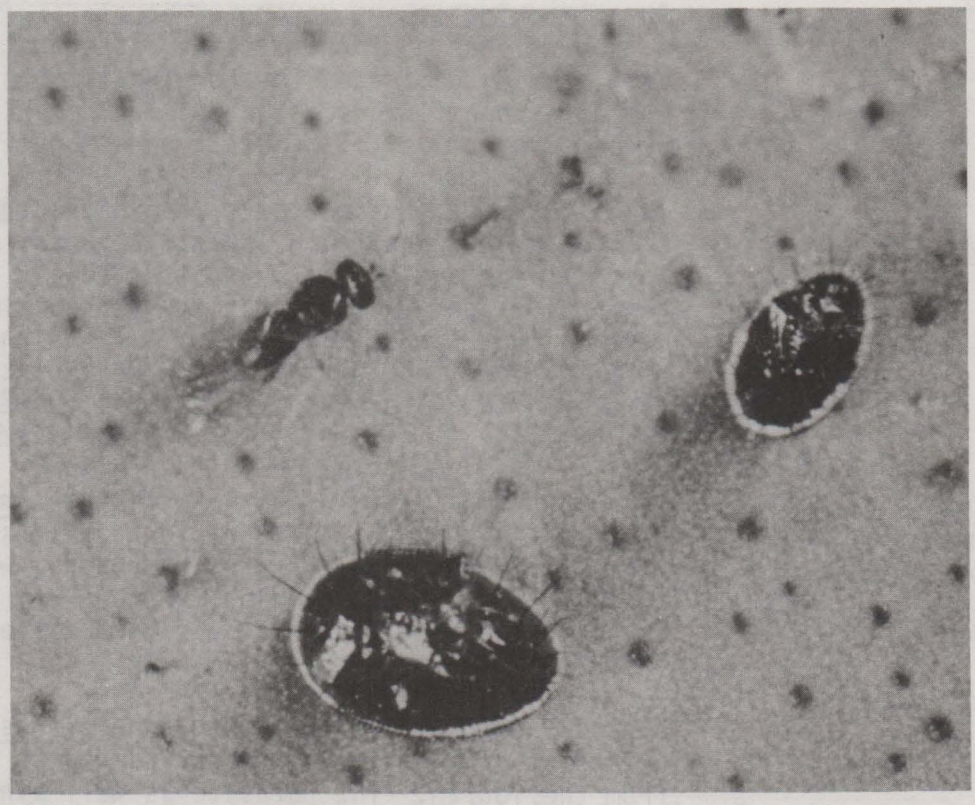
Natural Enemies

To combat the 1976 Florida infestation, Amitus hesperidum Silvestri and Prospaltella opulenta Silvestri were sent from the USDA Citrus Insects Laboratory, which had several species in culture in Mexico, to the Fort Lauderdale area. Establishment and dispersal were immediately successful (Selhime 1979).

A study by Dowell (1979) found that A. hesperidum oviposits in the first two instars of its host and emerges from the fourth. The parasite is well synchronized as measured in thermal units for development with its host. The 29 percent rate of parasitization of the 4th instar was the most important factor among all those that cause larval mortality, such as predators (a lady bird beetle Delphastus pusillus LeConte and Chrysopa spp.), wind, and desiccation. Without predators or parasites present a 23-fold population increase would be expected, with predators a 5-fold increase, and with predators and parasites a 5-fold decrease.

Adults of A. hesperidum live 2 days without food or water, 3-6 days under favorable conditions. Temperature limits are 10-45°C, matching well with those of its host. The short life span, temporal synchronization, and mature eggs at eclosion allow A. hesperidum to parasitize quickly a great number of hosts, if available. Densities in southern Florida were reduced from 60 to 1 immature host per leaf in 1 year's time, November 1976 to September 1977. In the past, the large reduction of populations was reversed again shortly afterward. Complete control depends on establishment of Prospaltella spp., which are much slower in development but also more lasting in effectiveness, being able to act upon very low host population levels (Cherry and Pastor 1980, Cherry 1979, Dowell 1979).

(Fig. F)



Adult of Amitis hesperidum and its host, A. woglumi pupae

For the above reasons, P. opulenta, brought from Mexico to El Salvador to successfully control A. woglumi (Quezada 1974), was introduced in Florida with A. hesperidum. This combination quickly reduced A. woglumi populations to noneconomical levels. Pesticide applications have been discontinued, saving State and Federal governments about $4 million annually (Lee 1979, Selhime 1979).

Despite the success of the biological control program, there remained the feeling in Florida, especially from industry, that complete eradication of this pest was cheaper than raising and distributing parasites. There was also the uneasiness as to whether the program would remain as successful should A. woglumi reach the commercial citrus areas. In 1979, successful eradication was estimated to be a 5-year effort at a cost of $5 million annually, as opposed to $1 million annually for the biocontrol program. The program will continue to be reviewed by industry and State scientific regulatory agencies. Trapping methods have been developed for this purpose (Anonymous 1979, Dowell and Cherry 1981).

Listed below are the various other natural enemies which have been found to attack A. woglumi throughout subtropical and tropical Asia (Clausen 1934).

Eulophid wasp parasites: Encarsia merceti Silvestri, Eretmocerus serius Silvestri, Prospaltella divergens Silvestri, Prospaltella smithi Silvestri, and Prospaltella sp.

Predators: Acletoxenus indica Malloch and Acletoxenus sp. nov., drosophilid flies; Chrysopa sp., a green lacewing; Cryptoblabes gnidiella Milliere, a pyralid moth; Cybocephalus sp., a sap beetle; Cryptognatha sp., Scymnus smithianus Silvestri, Scymnus sp., and Scymnus sp. near pallidicollis Mulsant, lady beetles (Hart et al. 1978).

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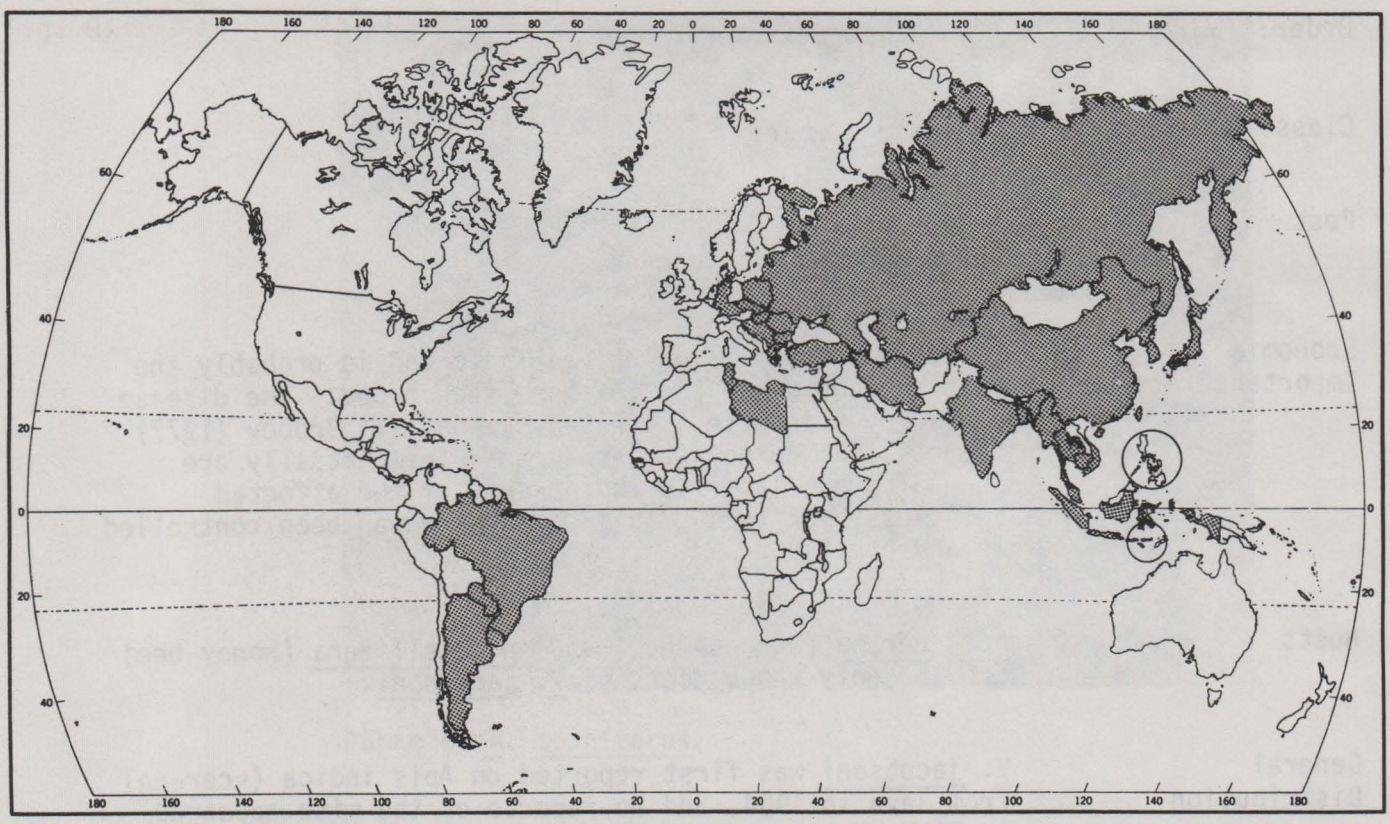
PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 16: VARROA MITE

Prepared by H. Shimanuki, USDA, Plant Protection Institute, Bioenvironmental Bee Laboratory, Bldg. 476, BARC-East, Beltsville, MD 20705

Order: Family	Parasitiformes: Varroidae
Class: Subclass	Arachnida: Acari
Pest	VARROA MITE *Varroa jacobsoni* Oudemans
Economic Importance	*Varroa jacobsoni* is an ectoparasite and is probably the most serious known pest of honey bee brood. The disease caused by this mite is called varroasis. Grobov (1977) reports that colony losses in apiaries initially are sporadic, but later 50-100 percent of the affected colonies are killed. This mite has never been controlled in any country.
Hosts	*Apis cerana* (a honey bee) and *Apis mellifera* (honey bee) are the only known hosts of *V. jacobsoni*.
General Distribution	*V. jacobsoni* was first reported on *Apis indica* (=*cerana*) from Java in 1904, and no reports of the mite appeared in literature until 1951, when the mite (as *Myromozercon reidi*) was found on *A. indica* in Singapore. The first report of *V. jacobsoni* attacking *A. mellifera* was in 1962-63 in Hong Kong and the Philippines (Oudemans 1904, Gunther 1951, Delfinado 1963). The following is the distribution for *V. jacobsoni*: Argentina (Montiel and Piola 1976), Bangladesh (Marin 1978), Brazil (Alves *et al.* 1978), Bulgaria (Velitchkov and Natchev 1973), Burma (Marin 1978), Cambodia (Ehara 1968), Peoples Republic of China (Ian Tzien-He 1965), Czechoslovakia (Samsinak and Haragsim 1972), Greece (Santas 1979), Hong Kong (Delfinado 1963), Hungary (Buza 1978), India (Phadke *et al.* 1966), Indonesia (Oudemans 1904), Iran (Crane 1979), Japan (Ehara 1968), Lebanon (Popa 1980), Libya (Crane 1979), North Korea (Tian Zai Soun 1967), Paraguay (Orosi-Pal 1975), Philippines (Delfinado 1963), Poland (Koivulehto 1976), Romania (Orosi-Pal 1976), Singapore (Gunther 1951), South Korea (Delfinado and Baker 1974), South Vietnam (Stephen 1968), Taiwan (Akratanakul and Burgett 1975), Thailand (Laigo and Morse 1969), Tunisia (Hicheri 1978), Turkey (Crane 1979), Uruguay (Grobov 1976), USSR (Breguetova 1953), West Germany (Ruttner 1977), and Yugoslavia (Santas 1979).

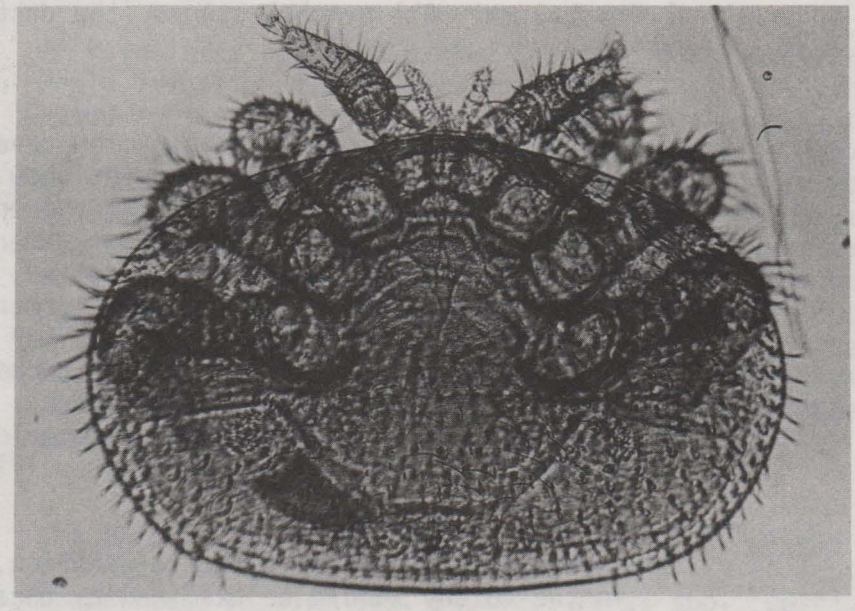


Varroa jacobsoni map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Characters

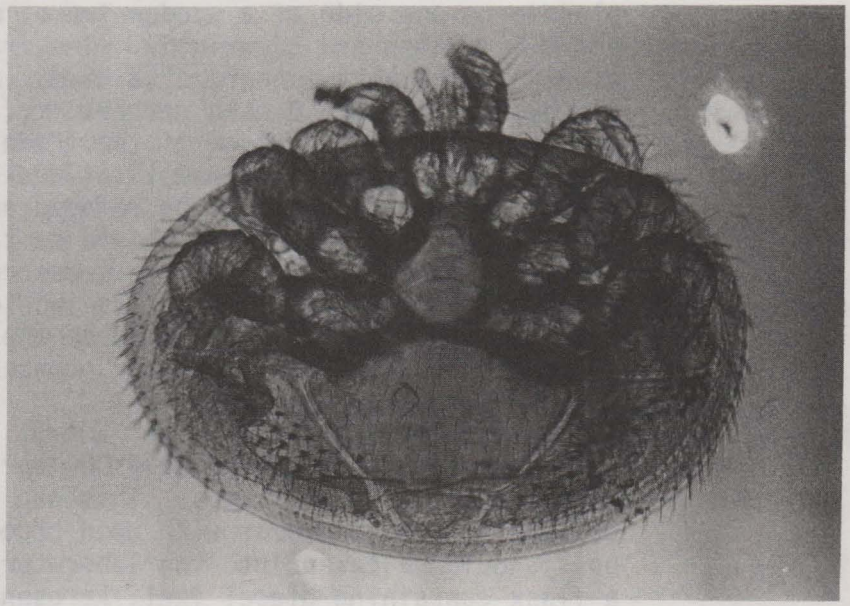
ADULTS - Females brown to dark brown, shaped like a crab, measuring 1.00-1.77 mm x 1.50-1.99 mm (fig. A and B). Only females are found on adult honey bees. Males yellowish and nearly round, measuring about 0.8-0.97 mm. Males are rarely encountered outside the honey bee brood cells.

(Fig. A)



V. jacobsoni: Female adult (dorsal view) (photo by D. A. Knox)

(Fig. B)



V. jacobsoni: Female adult (ventral view) (photo by D. A. Knox)

EGGS - 0.5 mm and white, usually found on the bottom or walls of the honey bee brood cell.

NYMPHS - V. jacobsoni has two nymphal stages, protonymph and deutonymph. Protonymphs of both sexes 0.7 x 0.7 mm. Deutonymphs differ in size; male 0.75 x 0.8 mm and female 1.0 x 1.3 mm. All nymphal stages (the destructive stage) white.

Characteristic Damage

The mites feed on the hemolymph of the developing honey bee brood. Heavily infested colonies show unusually large numbers of unsealed brood cells. At the entrances of affected colonies, dead or dying newly emerged bees are seen with malformed wings, legs, abdomens, and thoraxes. Sometimes even the apparently normal worker bees emerge smaller in size. Initial infestations may affect only 0.5 percent of the population and if left unchecked, more than 30 percent of the bees could be affected. Ultimately this leads to a decrease in population and could be reflected in a loss of honey crops and bees for pollination.

Detection Notes

1. In the initial phase of the infestation, all the brood in the colony should be examined by uncapping and removing the developing brood. As the mite population becomes established, honey bee colonies can be examined by the paper method. Attach a white sheet of paper or plastic on one side of a wooden frame, made with slats about 6 mm high and 13 mm wide. The frame should fit snugly on the bottom board of a hive. A hardware cloth, smaller than 8 mesh per 25.4 mm, should be stapled on the top surface of the frame. Then insert the entire unit into the hive. At weekly or monthly intervals the sheet should be removed and replaced with a new sheet. The old sheet should be taken to the laboratory and examined for the presence of mites. In addition, 100 or more brood cells should be examined for mites. Since the likelihood of the mites being present on drone brood is higher, concentrate on the capped drone brood.

   At the same time, approximately 500 nurse bees should be collected from the combs. This can best be done by collecting bees on combs with open brood cells. The bees should be taken into the laboratory and placed in a flask containing diesel fuel, kerosene, gasoline, alcohol, or hot water with detergent. Be sure there is enough fluid to completely immerse all the bees. Shake

the contents for 15-30 minutes on a shaker and filter first through a basket of 8 mesh per 25.4 mm or smaller to separate the bees from the liquid. Then filter again through several layers of cheesecloth. Finally, examine the cheesecloth for the presence of mites.

2. The extent of the infestation should be reported as the number of mites per 100 brood cells. For the filter method, report the finding as the number of mites per 500 bees. For the paper method, report the number of mites per colony.

3. Report the number of colonies sampled, the location of and the recent history of the hives. Information on where and when the colony was moved is especially important.

Biology

The biology of V. jacobsoni has not been thoroughly studied. Only the female mites are found on the adult honey bee. The mites can be found on the dorsal side of the thorax and abdomen of the bees. In addition, female mites can also be found in the intersegmental membranes of the abdomen on the ventral side of the bees. No harmful effects have been attributed to the mites on adult bees once they have emerged from the cells.

The female mite lays 1-38 eggs (average 7) in the cells of developing brood just prior to sealing. In 2 days, the protonymphs emerge and begin feeding on the larval hemolymph. The mites, as many as 20, attach themselves on the entire length of the larva. The entire life cycle, from egg to gravid female, lasts about 8-9 days, and mating occurs in the brood cell before the female emerges. The reproduction of mites is limited only by the availability of honey bee brood.

Natural Enemies

V. jacobsoni has no known enemies.

Controls

A number of fumigants have been tested against the mites (Grobov 1977). There is not one material that appears to be completely effective.

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 17: HONEY BEE MITE

Prepared by M. Delfinado-Baker and H. Shimanuki, USDA, Plant Protection Institute, Bioenvironmental Bee Laboratory, Bldg. 476, BARC-East, Beltsville, MD 20705

Order: Family — Acari: Tarsonemidae

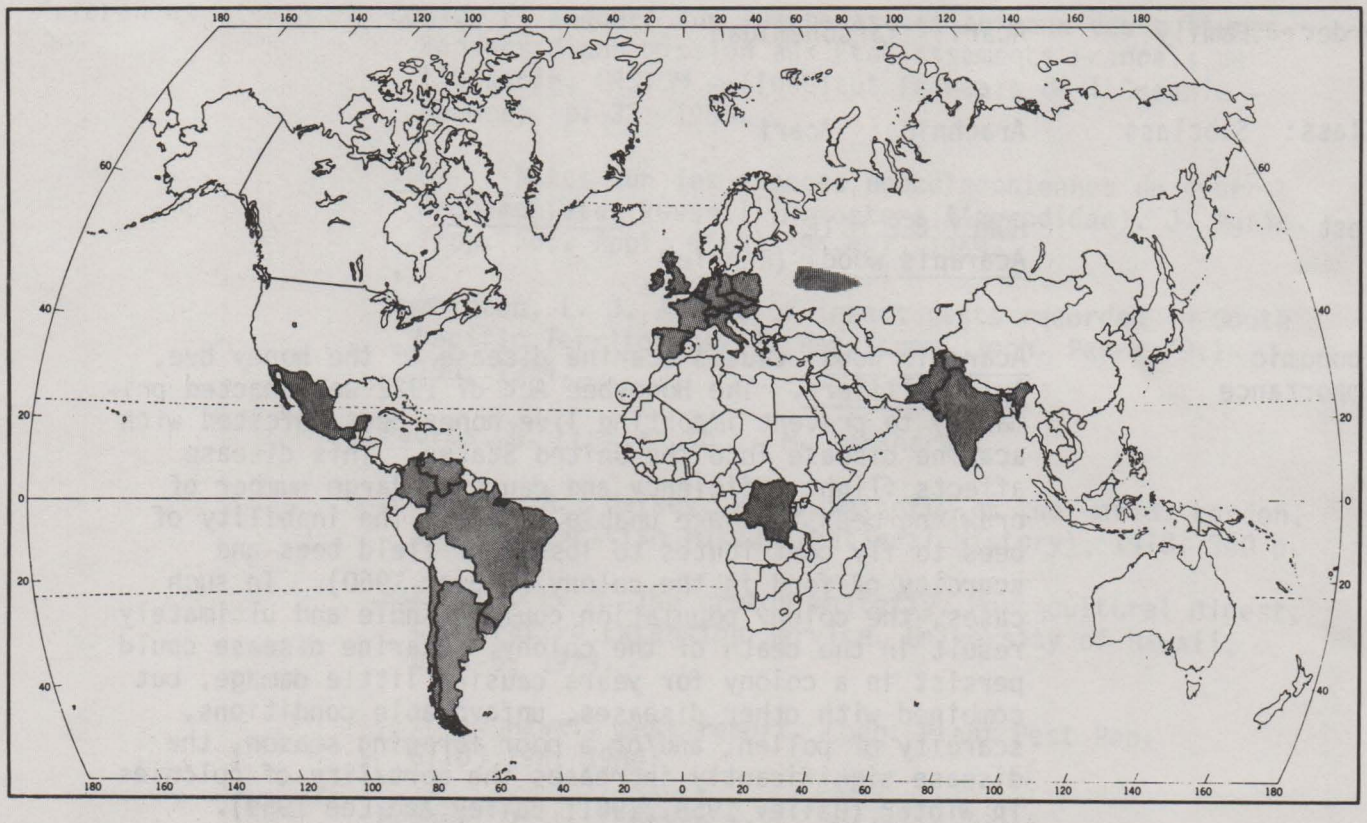
Class: Subclass — Arachnida: Acari

Pest — HONEY BEE MITE
Acarapis woodi (Rennie)

Economic Importance — *Acarapis woodi* causes acarine disease of the honey bee, *Apis mellifera*. The Honeybee Act of 1922 was enacted primarily to prevent importing live honey bees infested with acarine disease into the United States. This disease affects flight efficiency and causes a large number of crawling bees that are unable to fly. The inability of bees to fly contributes to losses of field bees and scarcity of food in the colony (Kaeser 1960). In such cases, the colony population could dwindle and ultimately result in the death of the colony. Acarine disease could persist in a colony for years causing little damage, but combined with other diseases, unfavorable conditions, scarcity of pollen, and/or a poor foraging season, the disease significantly increases the mortality of colonies in winter (Bailey 1958, 1961; Bailey and Lee 1959).

Hosts — *Apis mellifera* (honey bee) and *Apis cerana* (a honey bee) are the only known hosts of *Acarapis woodi*.

General Distribution — *Acarapis woodi* was first reported in 1921 on the Isle of Wight, England (Rennie 1921); it is now known in the USSR, and throughout most of Europe--Austria, Belgium, Czechoslovakia, France, Germany, Hungary, Ireland, Italy, Majorca, Netherlands, Poland, Scotland, Spain, Switzerland, and Wales (Jeffree 1959); Asia--India (Singh 1957, Kshirsagar 1966) and Pakistan (Ahmad 1981, personal communication); Africa--Canary Islands (Templer 1957) and Zaire (Benoit 1959); South America--Argentina, Chile, and Uruguay (Jeffree 1959), Venezuela (Vogelsang and Rodil 1957), Brazil (Nascimento et al. 1971), and Colombia (Menapace and Wilson 1980); and recently in Mexico (Zozaya 1981, personal communication).



Acarapis woodi map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

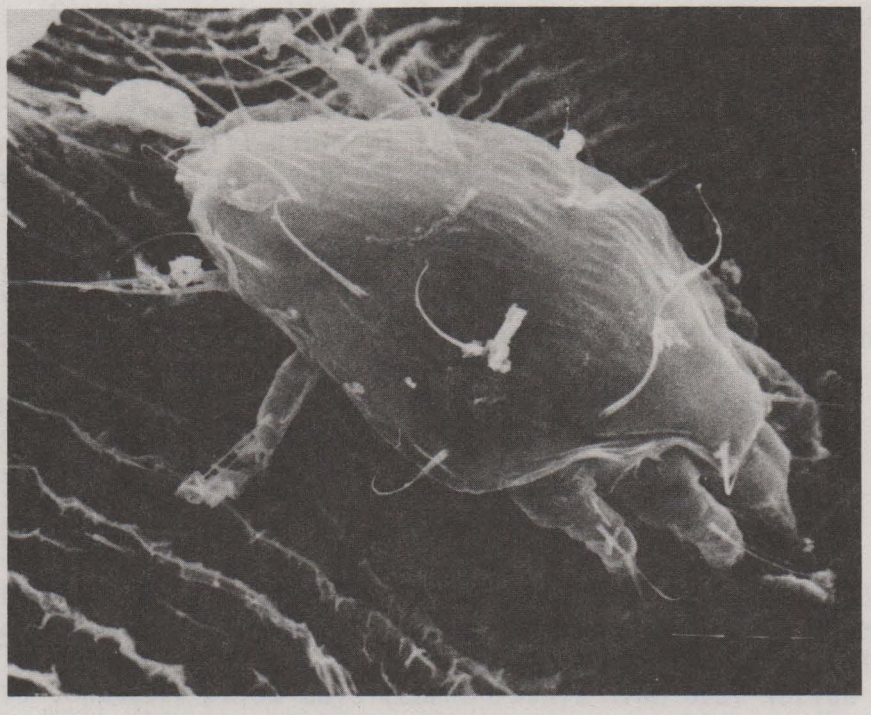
Characters

ADULT - The female of A. woodi infests the prothoracic tracheal system of the honey bee (fig. A). The mites are whitish in color and oblong. Female measures 143-174μ in length and 77-97μ in width (fig. B). The males are smaller, 125-136μ in length and 60-77μ in width. Both female and male lack sensillum or prodorsal prostigmatic organ. It has a beaklike gnathosoma with long, bladelike cheliceral stylets that are adapted for piercing and sucking and have a short and slender leg IV. The female leg IV has two long terminal setae and lacks claws; that of the male has one long terminal seta and one solenidion, and also lacks claws. The female of this mite is easily distinguished from other Acarapis species by having a shallow indentation on the posterior margin of the coxal plate (fig. C), and by the relatively short leg IV and anterior median apodeme. These morphological characters and the mites' presence in the bee trachea readily identify A. woodi, and should prevent confusion with the honey bee external Acarapis mites, externus and dorsalis (Michael 1962).

(Fig. A)

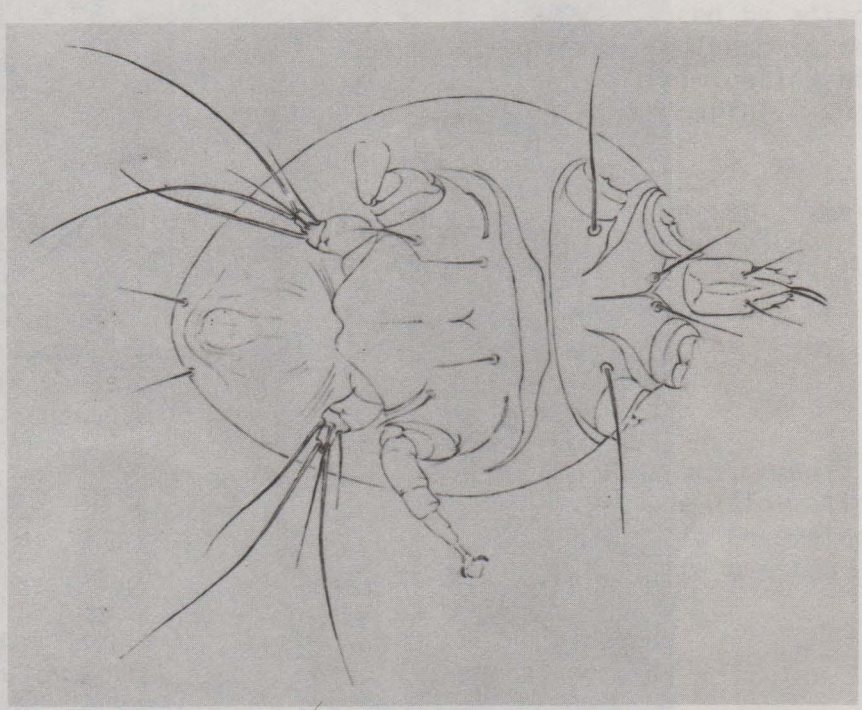
Acarapis woodi: A. Adults (SEM by W. E. Styer)

(Fig. B)



B. Female Acarapis woodi, dorsal view (SEM by W. E. Styer)

(Fig. C)



C. Female Acarapis woodi, ventral view (line drawing by E. W. Baker)

EGGS - The eggs are laid in the tracheae of the bee and are unusually large, about the size of a mature mite.

Characteristic Damage

The life span of infected bees is significantly shortened. Because they are unable to fly, large numbers of bees can be seen crawling on the ground near the hive. Diseased bees will often drop to the ground from the alighting board or while flying and may also gather in small clusters near the hive.

The trachea of diseased bees is obstructed by mites in different stages of development, as well as by mite debris. Feeding by the mites damages the walls of the trachea. The trachea, which are normally white, turn black. Tracheae that are normally elastic and flexible become stiff and brittle. Discoloration and atrophy of the flight muscles may also occur.

Another symptom is the abnormal "dislocated" position of the wings of walking bees. Infested colonies do not develop normally and may exhibit symptoms of dysentery and have a high mortality rate in the winter months. These colonies may often show an excessive swarming tendency.

Detection Notes

Because of the increased mortality of colonies in winter, it is important to detect the infestation before the winter clustering period. A positive diagnosis of the disease is made by examining the bee trachea for mites (fig. D). Suspect bees that appear unable to fly or have unhooked wings should be examined for mite infestation by removing the bee's head, front legs, and first skeletal ring.

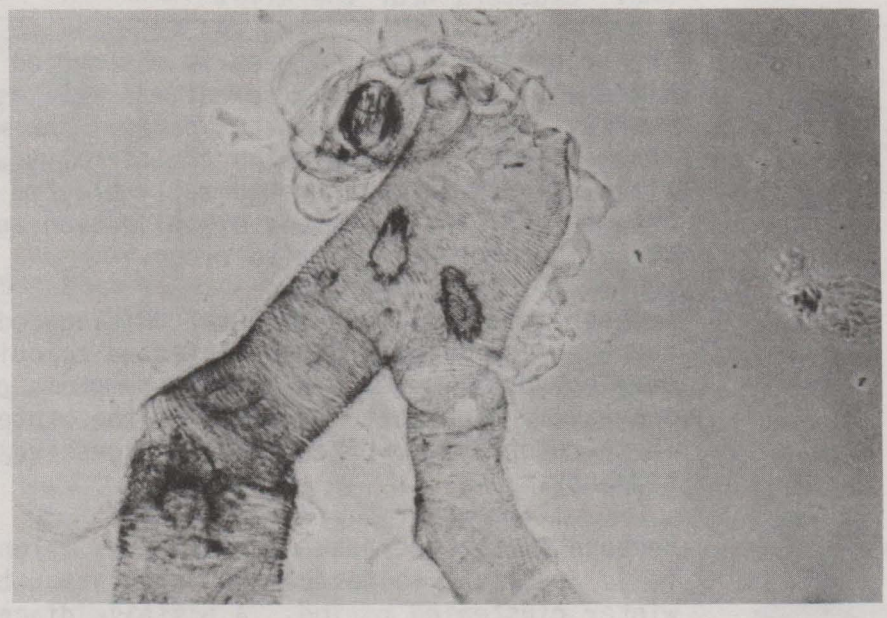
The trachea can be examined for mites with a dissecting microscope. The specimen can be cleared with a 5 percent KOH solution or lactic acid or lactophenol. The suspect tracheae can be examined more closely under coverslip on a slide (Colin et al. 1979).

Biology

The biology of this species has not been worked out in detail. The life cycle apparently is completed in the bee trachea. The development time for female mites from the egg to the nymph and gravid female is about 14 days.

The eggs are laid in the trachea of the bee one at a time. Each female can lay from 5 to 7 eggs. The egg stage may last 3-6 days, from which a six-legged larva emerges. According to Bailey (1968) the larvae complete their development and emerge as mature adults from the first thoracic spiracle. The adults move from one bee to another until they encounter a young bee before entering the trachea. Bees less than 9 days old are the most susceptible (Lee 1963).

(Fig. D)



D. Acarapis woodi in trachea (photo by W. E. Styer)

Natural Enemies

Acarapis woodi has no known enemies.

Controls

Chemical controls are available in foreign countries for the control of this pest. One would have to check with the proper authorities to obtain proper registration and the latest recommendations for treatment.

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 18: SOUTH AMERICAN FRUIT FLY

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 402, Hyattsville, MD 20782

Order: Family

Diptera: Tephritidae

Pest

SOUTH AMERICAN FRUIT FLY
Anastrepha fraterculus (Wiedemann)

Economic Importance

Anastrepha fraterculus is a serious pest of cultivated fruits in many parts of South America, and apparently the most injurious species of the genus *Anastrepha*. In Argentina, it is considered to be the most important pest in all citrus areas. Many varieties of fruits are attacked, and sometimes vegetables and nuts (Ebeling 1959, Oakley 1950).

Hosts

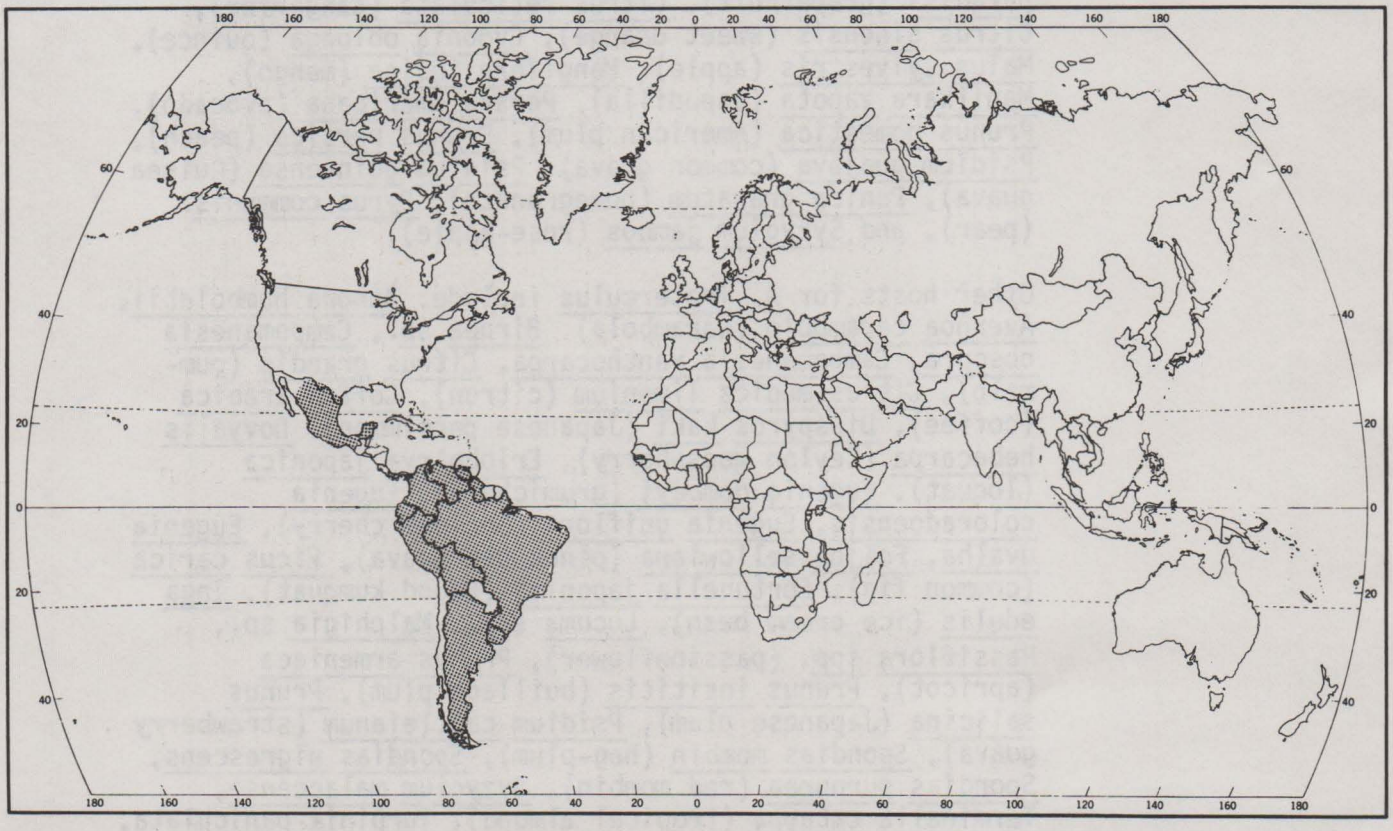
This species shares the following hosts with *Anastrepha ludens* (PNKTO #19): *Annona cherimola* (cherimoya), *Citrus aurantium* (sour orange), *Citrus medica* (citron), *Citrus paradisi* (grapefruit), *Citrus reticulata* (tangerine), *Citrus sinensis* (sweet orange), *Cydonia oblonga* (quince), *Malus sylvestris* (apple), *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Persea americana* (avocado), *Prunus domestica* (American plum), *Prunus persica* (peach), *Psidium guajava* (common guava), *Psidium guineense* (Guinea guava), *Punica granatum* (pomegranate), *Pyrus communis* (pear), and *Syzygium jambos* (rose-apple).

Other hosts for *A. fraterculus* include: *Annona humboldtii*, *Averhoa carambolo* (carambola), *Birnea sp.*, *Campomanesia obscura*, *Campomanesia xanthocarpa*, *Citrus grandis* (pummelo), *Citrus medica limonium* (citron), *Coffea arabica* (coffee), *Diospyros kaki* (Japanese persimmon), *Dovyalis hebecarpa* (Ceylon gooseberry), *Eriobotrya japonica* (loquat), *Eugenia dombeyi* (grumichoma), *Eugenia coloradoensis*, *Eugenia uniflora* (Surinam cherry), *Eugenia uvalha*, *Feijoa sellowiana* (pineapple guava), *Ficus carica* (common fig), *Fortunella japonica* (round kumquat), *Inga edulis* (ice cream bean), *Lucuma* spp., *Malphigia* sp., *Passiflora spp.* (passionflower), *Prunus armeniaca* (apricot), *Prunus insititis* (buillace plum), *Prunus salicina* (Japanese plum), *Psidium cattleianum* (strawberry guava), *Spondias mombin* (hog-plum), *Spondias nigrescens*, *Spondias purpurea* (red mombin), *Syzygium malaccense*, *Terminalia catappa* (tropical almond), *Turpinia paniculata*, *Vitis vinifera* (wine grape), and *Ximenia americana* (tallow-wood).

Of these hosts, the Surinam cherry, peach, and guava are preferred. The Mexican form attacks guavas and peaches, but does not appear to attack citrus, while in South America citrus is severely attacked. Tropical almond is attacked in Mexico but has not been reported as a host in South America (Oakley 1950, Weems 1980, Malavasi et al. 1980).

General Distribution

A. fraterculus is known to occur in Argentina, Bolivia, Brazil, British Guiana, Colombia, Ecuador, Panama, Peru, Tobago, Trinidad, Uruguay, and Venezuela. (Commonwealth Institute of Entomology 1958). This pest is also known to range northward to Northern Mexico and the Rio Grande Valley of Texas, where it is considered by Baker et al. (1944) as a distinct form of the species, based on different host responses (as noted in the hosts section) and possible morphological differences.



Anastrepha fraterculus map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Characters

Field Description

ADULTS - About 12 mm long (not including ovipositor of female), wing expanse about 25 mm. Body rust yellow or brownish yellow, with three sulfur yellow longitudinal stripes on thorax. Wings clear except for characteristic but variable yellow-brown pattern. Inverted V of wing separated from main pattern. Ovipositor stout and shorter than abdomen, tapered regularly toward tip and covered with coarse, black hairs.

Technical Description

ADULTS (fig. A) - Small to rather small, yellow brown. Mesonotum 2.75-3.3 mm long, yellow brown; the humerus, median stripe widened posteriorly anterior to acrostichal bristles and barely includes these bristles; lateral stripe from transverse suture to scutellum bright yellow; pleura yellow and yellow brown; metanotum and postscutellum rather broadly blackened laterally. Macrochaetae yellow brown to black; pile yellow brown. Sternopleural bristle slender. Wing 5.35-7.2 mm long, bands yellow orange and brown. Costal band typically separated from S band, wing pattern with considerable variation.

Female terminalia: Ovipositor sheath 1.65-2.1 mm long, stout, tapering apically, spiracles about 0.7 mm from base. Rasper rather small patch of hooks in four or five rows. Ovipositor 1.5-1.95 mm long, stout, base distinctly widened, tip narrower beyond end of oviduct and before serrate portion, serrations blunt and rounded, extending over half length of tip, sometimes less.

Male terminalia: Tergal ratio about 0.87; clasper about 0.35 mm long, moderately stout basally, greatly flattened apically, apical portion somewhat narrowed, with rather blunt apex; teeth slightly basad of middle (Stone 1942).

EGGS - Creamy white, elongated, tapered at end. About 1.4 mm long, 0.2 mm wide at midpoint.

LARVAE - When mature about 8-10 mm long, 1.0 mm wide, pale yellowish white, tapered slightly toward cephalic end.

PUPAE - About 4.5-6.0 mm long, 2.0-2.5 mm wide, cylindrical, dull luteous to reddish yellow or dark red.

Fruit fly larvae and pupae are difficult to identify to species level, and much more research is needed. Adult identification is usually based on the female; in most cases males are still indeterminable (Weems 1980).

(Fig. A)

A. fraterculus: A. Female adult

Characteristic Damage

Fruit fly damage is often very similar. For this species damage begins when the ovipositing female punctures the fruit for egg laying. The larvae feed on the internal tissues causing breakdown and premature drop of the fruit. The oviposition punctures often heal over and become invisible in cases of mature hosts. Sometimes sap exudation and discolored spots are present. The larvae feed in immature, ripening, or ripe fruits. Usually this feeding is in the pulp, and occasionally on immature seeds. A single larva can render a fruit worthless (Oakley 1950).

Detection Notes

1. In warm weather look for adults on fallen fruit.

2. Larvae may be found by cutting fruit and looking for larvae in the pulp.

3. McPhail traps (with Mexican fruit fly bait) have been successful in catching A. fraterculus.

Biology

This species varies considerably by season as well as by country. The preoviposition period also varies. In Peru, one egg at a time is usually laid by a female. Up to 50 eggs may be laid in a single fruit, with the total number depending on maturity and variety of the host fruit. Adults live for about a month. Length of immature stages are as follows: Egg, 3 days in summer and 6 in winter; larva, 15-20 days in summer and 20-25 days in winter. In exceptional cases adults have been known to emerge from pupae after 12, 14, and 18 months. Six to seven generations develop annually.

In general the factors that influence the life cycle of this species (and most fruit flies) include latitude, season, temperature, rainfall, humidity, availability of food, and natural enemies (U.S. Department of Agriculture 1965, Oakley 1950).

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 19: MEXICAN FRUIT FLY

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 402, Hyattsville, MD 20782

Order: Family — Diptera: Tephritidae

Pest — MEXICAN FRUIT FLY
Anastrepha ludens (Loew)

Economic Importance — *A. ludens* is a serious pest of citrus and mango in northeastern Mexico. Its annual flight from Mexico has established damaging infestations in southern Texas during the winter and spring months. These infestations are usually eradicated naturally by hot weather and the absence of summer hosts. PPQ maintains survey, regulatory, and control programs including grove inspection, spray applications, trapping, fruit fumigation, and the certification of fruit shipped to or through designated citrus areas of Arizona, California, Florida, and Louisiana.

Arizona and California are vulnerable to infestation by the flight of these flies across the international border from northwestern Mexico where large quantities of host material are received from the interior of Mexico. In addition to the many trappings in this area, *A. ludens* has been trapped once in Florida, February 1972, at Sarasota (as given in a letter from H. V. Weems, Jr., to G. C. Steyskal). PPQ has worked in close cooperation with the Mexican Sanidad Vegetal to prevent establishment in northwestern Mexico. This cooperative undertaking has included the operation of traps, sterile fly release, fruit treatment, road station inspection operations, and quarantine enforcement (U.S. Department of Agriculture 1965, Weems 1967).

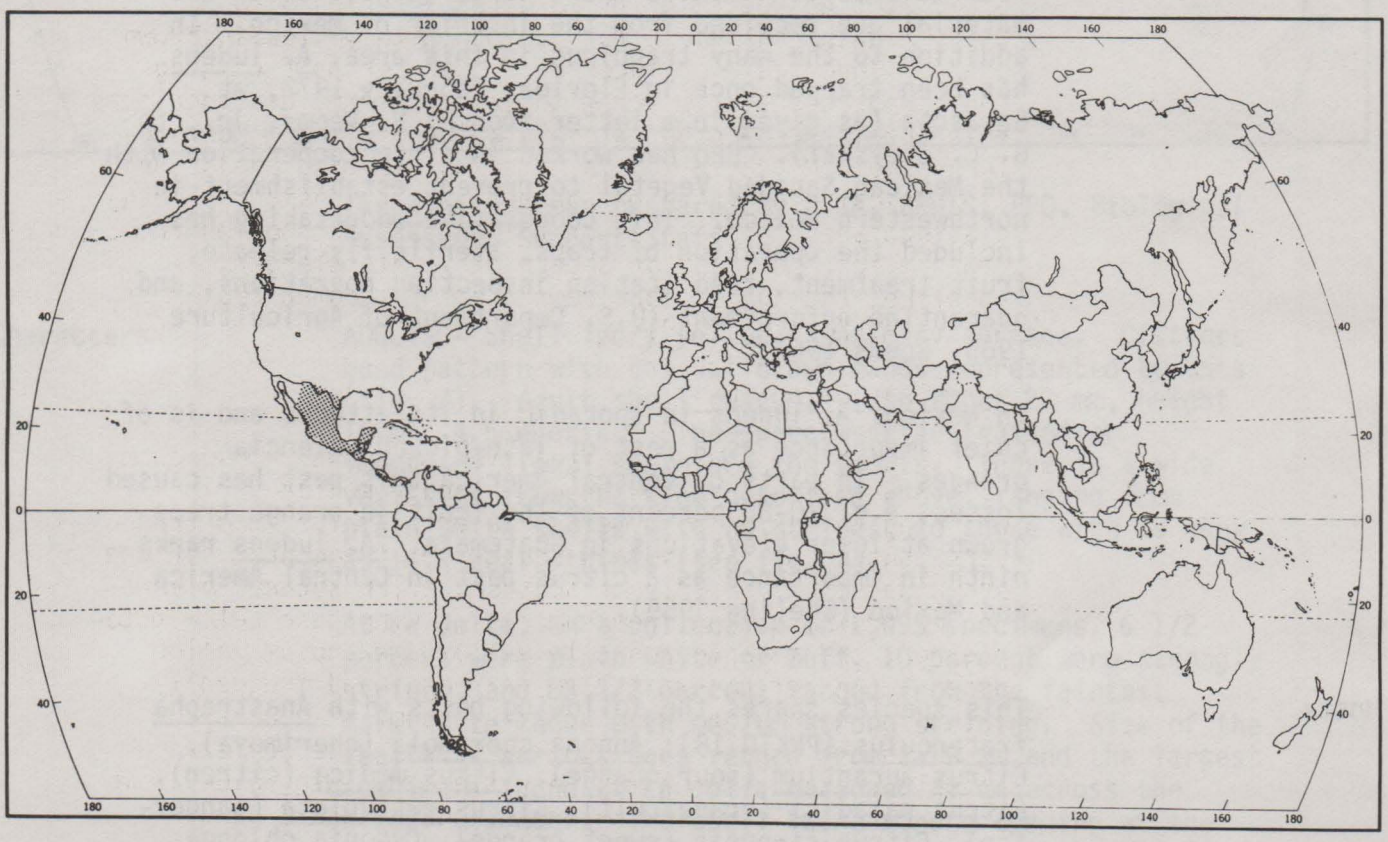
In Mexico, *A. ludens* is sporadic in its attacks and is of chief importance as a pest of late-picked Valencia oranges. In parts of Central America this pest has caused losses, e.g. 70-80 percent of the fruit in orange trees grown at lower elevations in Guatemala. *A. ludens* ranks ninth in importance as a citrus pest in Central America and Mexico (Ebeling 1959).

Hosts — This species shares the following hosts with *Anastrepha fraterculus* (PNKTO 18): *Annona cherimola* (cherimoya), *Citrus aurantium* (sour orange), *Citrus medica* (citron), *Citrus paradisi* (grapefruit), *Citrus reticulata* (tangerine), *Citrus sinensis* (sweet orange), *Cydonia oblonga* (quince), *Malus sylvestris* (apple), *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Persea americana*

(avocado), Prunus domestica (American plum), Prunus persica (peach), Psidium guajava (common guava), Psidium guineense (Guinea guava), Punica granatum (pomegranate), Pyrus communis (pear), and Syzygium jambos (rose-apple).

Other hosts for A. ludens include: Annona muricata (soursop), Annona reticulata (custard-apple), Carica papaya (papaya), Casimiroa edulis (white sapote), Casimiroa tetrameris, Citrus aurantifolia (sweet lime), Citrus grandis (pummelo), Diospyros texana (Texas persimmon, chapote), Gurania suberosa, Inga inicuil, Malpighia mexicana, Mammea americana (mammee-apple), Pouteria sapota (sapota), and Sargentia greggii (yellow chapote) (Oakley 1950, Weems 1967 and 1980).

A. ludens will also infest a number of other fruits and vegetables under laboratory conditions. The fruit of the avocado does not appear to be a primary host, but infested fruits have been intercepted at the Mexican border



Anastrepha ludens map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

stations. If large numbers of Mexican fruit flies developed on other nearby hosts, they might also become a pest of the avocado (Ebeling 1959, U.S. Department of Agriculture 1965).

General Distribution

A. ludens is found in Costa Rica, Guatemala, Mexico, and the Rio Grande Valley of Texas (Commonwealth Institute of Entomology 1958, Ebeling 1959). This species is subtropical rather than tropical ranging southward only at higher elevations through Central America and into northern South America (Weems 1967).

Characters

Field Description

ADULTS - About 7-10 mm long, larger than housefly, green eyes, yellowish brown body with small black marking. Somewhat lighter longitudinal markings on thorax, especially on newly emerged flies. Small median dark brown spot on posterior of mesothorax behind wings. Wings transparent where not striped with yellowish-brown bands. Inverted V on lower part of outer half of wing (not connected at tip nor with main pattern) distinguishes this species from other closely related flies. Forward-curved vein M near wing tip, distinctive wing bands, and cylindrical elongation of abdomen (the ovipositor sheath) distinguishes the females of all Anastrepha species from other flies. Ovipositor sheath of female slender, tubelike, and longer than remainder of abdomen (Baker et al. 1944, Ebeling 1959).

Technical Description

ADULTS (fig. A) - Medium sized, yellow brown. Mesonotum 2.75-3.6 mm long, yellow brown, slender median stripe widening posterior to humerus, lateral stripe from transverse suture to pale yellow scutellum; frequently diffuse brownish spot in middle of scutoscutellar suture; pleura yellow brown, stripe from humerus to wing base below notopleuron, and metapleuron pale yellow; metanotum yellow brown, sides of postscutellum darkened, and frequently extending down along sides of metanotum. Macrochaetae brownish black; pile pale yellow brown. Sternopleural bristle present, sometimes very slender. Wing 6.6-9.0 mm long, bands pale yellowish brown; costal and S bands touching vein R or narrowly separated; V band separated from S band or very narrowly connected, usually rather pale anteriorly.

(Fig. A)

A. ludens: A. Female adult

Female terminalia: Ovipositor sheath 3.4-4.7 mm long, tapering to apical third, and somewhat expanded and depressed; spiracles 0.85-1.35 mm from base. Rasper of moderate-sized hooks in five to seven rows. Ovipositor 3.35-4.7 mm long, moderately stout, tip elongate, tapering, with few rounded serrations on apical half; shaft at extreme base abruptly widened.

Male terminalia: Tergal ratio about 1:12; clasper about 0.37 mm long, stout basally, flattened apically; outer margin somewhat convex to subtruncate apex; inner margin nearly straight; teeth slightly proximad of middle (Stone 1942).

EGGS - White, spindle shaped.

LARVAE - White, maggotlike, and pointed at one end with visible black mouth hooks. Legless, moving by contraction and expansion of body segments. Length for mature specimens about 9-11 mm long, and 1.5 mm in diameter.

PUPAE - Brown, about 2 mm long.

Fruit fly larvae and pupae are difficult to identify to species level, and much more research is needed. Adult identification is usually based on the female; in most cases males are still indeterminable (Weems 1980).

Characteristic Damage

Fruit fly damage is often very similar. For this species damage begins when the ovipositing female punctures the fruit for egg laying. The larvae feed on the internal tissues causing breakdown and premature drop of the fruit. The oviposition punctures often heal over and become invisible in cases of mature hosts. Sometimes sap exudation and discolored spots are present. The larvae feed in immature, ripening, or ripe fruits. Usually this feeding is in the pulp, and occasionally on immature seeds. A single larva can render a fruit worthless (Oakley 1950).

Detection Notes

1. In a detection survey where no fruit flies are known to be present, trap density will vary considerably. More importance should be given to the probability of the fruit fly being present in a given area than to maintaining uniform distance between traps. Generally where preferred hosts are found, traps should be no further than 0.8 km apart. Density should be greatest around areas where flies are likely to be introduced.

2. Areas with high humidity, abundant shade, white grapefruit, and vegetated areas are more likely to attract the Mexican fruit fly.

3. Look for colorful picture-wing flies on fallen fruit.

4. Specific baits and trapping details are available in the PPQ Mexican Fruit Fly Survey Manual (U.S. Department of Agriculture 1965).

Biology

Under laboratory conditions, the first mating began 11-25 days after emergence, and oviposition a few days later. Eggs hatched in about 7 days at a mean temperature of 22°C and larvae developed in the laboratory in 18.5-35 days. The prepupal and pupal stages (in soil) lasted 32 days at 18°C and 21 days at 22°C. Adult life varied greatly in tests, sometimes prolonged to 6 months. The average life cycle normally occupies about 3 months with three

generations developing annually (Oakley 1950). The number of generations per year can range from 1 to over 12. The adult female punctures the rinds and skins of fruits and vegetables then inserts 2-10 eggs. A single female may produce several hundred eggs. The larvae feed by burrowing in the pulp for 10 days to 6 weeks before completing growth. The larvae then leave the fruit and enter the soil within 3-5 cm of the surface (or sometimes in other protected places) and form puparia. Pupation may be completed in 10-50 days. The adults emerge from the puparia and feed on liquids and soluble solids. They mate and the females lay eggs and start the cycle again. The adults overwinter and some species may oviposit successfully after 10 months of inactivity.

Generally, the time elapsed in southern Texas in the spring between oviposition and the emergence of the larva from grapefruit is approximately 3 weeks; the pupal period is about the same. These intervals may vary considerably if conditions are unfavorable, but A. ludens does not naturally spend long periods as a larva in the hosts, nor can the pupal period be extended greatly beyond 90 days, even under the most unfavorable conditions. The adult may live for many months. A. ludens is believed to be capable of flying over 161 km, at least in a series of flights.

In general the factors that influence the life cycle of this species (and most fruit flies) include latitude, season, temperature, rainfall, humidity, availability of food, and natural enemies (U.S. Department of Agriculture 1965, Oakley 1950).

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 20: ORIENTAL FRUIT FLY

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 402, Hyattsville, MD 20782

Order: Family — Diptera: Tephritidae

Pest — ORIENTAL FRUIT FLY
Dacus dorsalis (Hendel)

Economic Importance

This fruit fly, one of the world's most destructive pests of soft fruits, was introduced into the Hawaiian Islands about 1945 and developed to high populations by 1948. Based on what has occurred in Hawaii, this species is more dominant and aggressive than the melon fly, *Dacus cucurbitae* Coquillett or the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann). It seems certain that under favorable conditions, *D. dorsalis* could survive and reach damaging numbers in the southern parts of California, Texas, or Florida (Armitage 1949, Boyce 1949).

Females have invaded fruit stands inside stores and laid their eggs in imported fruits. Although bananas are not usually attacked by fruit flies in South India, larvae were found tunneling in the pulp of bananas brought from Bangalore. It is considered to be one of the most important tephritids in India.

Although most literature does not indicate *D. dorsalis* to be as important to citrus as *C. capitata*, a report from Sri Lanka noted that unprotected grapefruit had been heavily attacked. This species has also been cited as a serious citrus pest in Taiwan (Oakley 1950b). In Hawaii, *D. dorsalis* is destructive to all marketable fruit crops except pineapple and strawberries (Drew 1978).

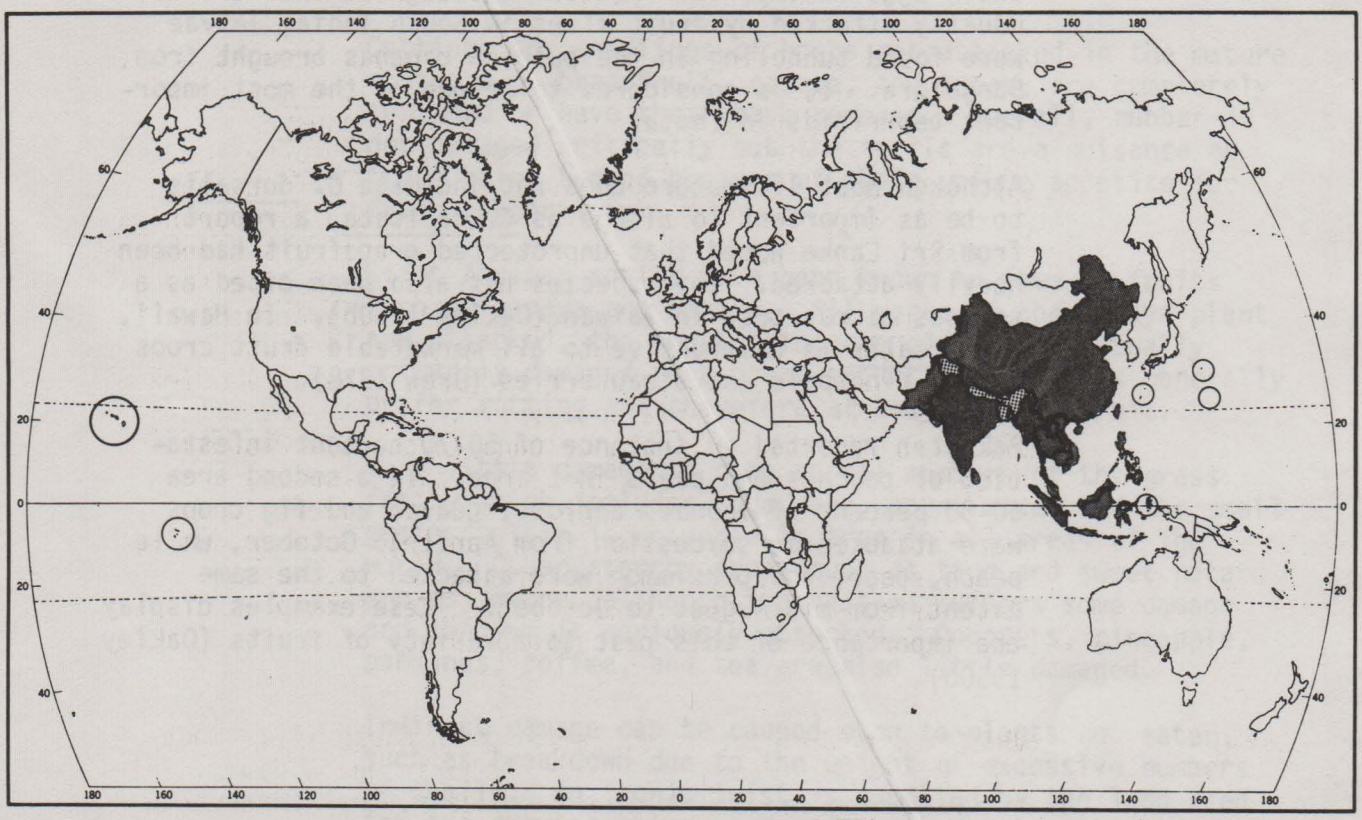
Pakistan reported an instance of 50-70 percent infestation of peaches and pears in 1 area. In a second area 50-80 percent of loquat, apricot, guava, and fig crops were attacked in succession from April to October, while peach, pear, and persimmon were attacked to the same extent from mid-August to October. These examples display the importance of this pest to a variety of fruits (Oakley 1950b).

General Distribution

The presence of D. dorsalis in Australia has not been determined. However, several species very similar in appearance to it occur in northern Australia and are of considerable economic importance.

Other distribution includes Bangladesh, Burma, Bonin Islands (Chichi-Zima), Caroline Islands (Kusie and Ponape), China (southern), Cambodia, India, Indonesia (Amboina, Batavia, Borneo, Celebes, Halmahera, Java, Sumatra, and Timor), Laos, Marianas Islands (Rota, Saipan, and Tinian), Malaysia, Nepal, Okinawa, Pakistan, Philippines, Ryukyu Islands, Sri Lanka, Taiwan, Thailand, and Vietnam. In the United States D. dorsalis is known from Guam and Hawaii (Oakley 1950b, California Department of Food and Agriculture 1971, Drew 1978).

There have been several instances of adult flies trapped in California beginning in 1960 (1966, 1967, 1969, and practically every year since) and some trappings in



Dacus dorsalis map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Florida, but only in 1974 have larvae been found (in the San Diego, California area) on the mainland. Apparently, the fly is brought to the California mainland regularly by some means, presumably from Hawaii, but has been eradicated successfully each time (U.S. Department of Agriculture 1970 and personal communication).

Hosts

Included in a host list of over 175 species are over 100 kinds of fruits and vegetables attacked by D. dorsalis. Since the host list is so extensive and varied the fruiting portion of almost any plant could probably be attacked by this fly (Boyce 1949).

Some of the most common hosts are the following citrus, stone, and pome fruits: Citrus spp. (grapefruit, lemon, lime, pummelo, sweet and sour orange, and tangerine); Prunus spp. (almond, apricot, common plum, damson plum, Japanese plum, myrobalan plum, and peach); Malus sylvestris (apple); and Pyrus communis (pear).

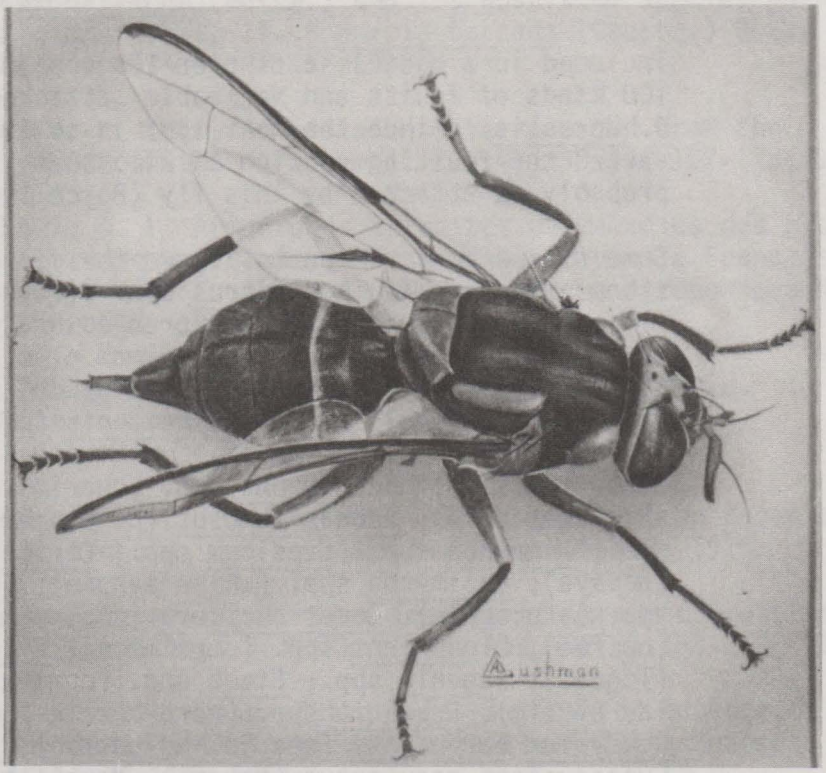
Other hosts include: Annona spp. (cherimoya, custardapple, and sugarapple); Ananas comosus (pineapple); Artocarpus spp.; Averrhoa spp.; Capsicum spp.; Carica papaya (papaya); Casimiroa spp. (white sapote); Chrysophyllum spp. (starapple); Cocos nucifera (coconut); Coffea spp. (coffee); Diospryros spp. (persimmon); Eriobotrya japonica (loquat); Eugenia spp.; Ficus spp. (common fig, Indian laurel fig); Fragaria spp. (strawberries); Garcinia spp.; Gossypium barbadense (sea island cotton); Inocarpus spp.; Lycopersicon esculentum (tomato); Mangifera indica (mango); Momordica spp.; Musa paradisiaca (banana); Olea europaea (olive); Opuntia spp. (pricklypear); Passiflora spp. (granadilla); Persea americana (avocado); Phoenix dactylifera (date palm); Pimenta dioica (allspice); Pimenta racemosa (bay rum tree); Pouteria campechiana (canistel); Punica granatum (pomegranate); Solanum spp.; Spondias spp.; Syzygium spp.; Terminalia spp.; and Ziziphus spp. (jujube) (Oakley 1950b, California Department of Food and Agriculture 1971).

Characters

ADULT - Length about 8 mm, larger than house fly. Body dull yellow with dark markings on thorax and abdomen. Median stripe forms "T" shape with additional transverse dark band on abdomen. Wings clear and narrow (an outstanding exception to the rule for fruit flies), with dark band along forward margin and short diagonal band near base (U.S. Department of Agriculture 1965, Drew 1978).

Both sexes show aging characteristics. One day old male testes white, gradually increase in size, then intensify to bright orange. After 5 days, testes later turn yellow, and after 10 days, become orange again and larger. Newly emerged flies generally light in color, gradually harden, and become darker with age (Maehler 1969).

(Fig. A)



D. dorsalis: A. Female adult

LARVA - Length about 10 mm, creamy white, headless, typical maggot shape without dark markings at broadened posterior end.

PUPA - Oval, length about 5 mm, tan to dark brownish yellow.

Larvae and pupae of most Dacus species are virtually impossible to identify to the species level with few exceptions. There are no morphological characters that can be used to distinguish these stages from most other Dacus species (Drew 1978).

EGG - Length slightly over 1 mm, slender, white, elliptical (California Department of Food and Agriculture 1971).

Characteristic Damage

Under population pressure, female adults will oviposit in any fleshy plant tissue. Oviposition in stems causes splitting and ultimate death of the plant (Armitage 1949).

Egg punctures in fruit allow decay organisms to enter. Larval feeding reduces the interior of fruit to a rotten mass. Conspicuous holes are left in the fruit when larva exit the fruit and drop to the ground to pupate (Oakley 1950b).

Detection Notes

1. Watch for prematurely dropped fruit and fruit with softened, darkened, and broken-down areas. Cut open suspect fruit to search for larvae (headless maggots).

2. Submit for identification any larvae from fruit pulp, especially if part of fruit is undamaged.

3. Watch for egg punctures in fruit. They are very small and may be surrounded by small elevated craters, or exude droplets of liquid. Emerging larvae leave larger holes.

4. Adults may be trapped with Steiner traps, in or near host trees, baited with methyl eugenol from May to October. Oil of citronella is also a good attractant.

5. Insects in the trap should be dipped out individually and submitted in 70 percent alcohol vials for identification (California Department of Food and Agriculture 1971).

Biology

Development from egg to adult takes less than 30 days. Large numbers of eggs are inserted into host fruit tissue. Larvae develop within the fruit and emerge fully developed, then enter the soil where pupation occurs. There is no hibernation period. Tests in Taiwan showed that the egg stage lasted an average of 27.1 hours at 32°C and 264 hours at 12°C, while immatures did not develop at temperatures lower than 12°C. Tests in Hawaii showed that the larval stage lasted 11-15 days and the pupal stage 9 days. Only three complete generations developed in Taiwan; while in Hawaii development was almost continuous.

The life cycle of D. dorsalis may be completed in 21 days in Hawaii under favorable conditions, but can be greatly prolonged up to 6 months at cool temperatures. The length of each stage varies under differing environmental conditions, with temperature being the chief factor. Ecological studies indicate that this species can adapt to a wide range of climatic conditions.

Mating begins at twilight and continues until dawn if temperatures are at least 17°C, not occurring in daylight except on dark overcast days. After mating, the female passes through a preoviposition period before laying fertile eggs. Females prefer to oviposit in mature or nearly mature fruit (green fruit may be attacked), usually after 10 days. One female will usually oviposit 500-1,000 eggs, 5-10 in a single puncture. The life cycle is usually completed in fallen fruit.

The adult's average life span is 90 days or less in nature, where it is acted upon by natural enemies, food limitations, and weather. Under laboratory conditions, the life span has reached 422 days.

Spread of the fruit fly is effected by adult flight, by wind, and by man's movement of infested hosts (Oakley 1950a and 1950b, Maehler 1969).

Control

Chemicals, sanitation, and trapping have been used to control D. dorsalis, but at considerable expense.

Natural Enemies

The search of the Southeast Asia area for natural enemies by the Hawaii Board of Agriculture and Forestry obtained 25 parasites (22 Opius spp.), in addition to the 4 already established in Hawaii, and the 2 predators. A total of 29 parasites and 1 predator species or varieties was released and 7 became established.

Of these, only Opius oophilus Full., an egg parasite obtained from Northern Borneo, Taiwan, and Thailand, was effective for control. This species is also found in Northern Philippines and Java. Full economic control was not obtained, but considerable reduction of D. dorsalis populations in guavas, the main host reservoir, was effected. Many formally infested hosts were free from attack. This parasite was also effective against the Mediterranean fruit fly (Clausen et al. 1965).

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 21: SEYCHELLES FLUTED SCALE

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Order: Family

Homoptera: Margarodidae

Pest

SEYCHELLES FLUTED SCALE
Icerya seychellarum (Westwood)

Economic Importance

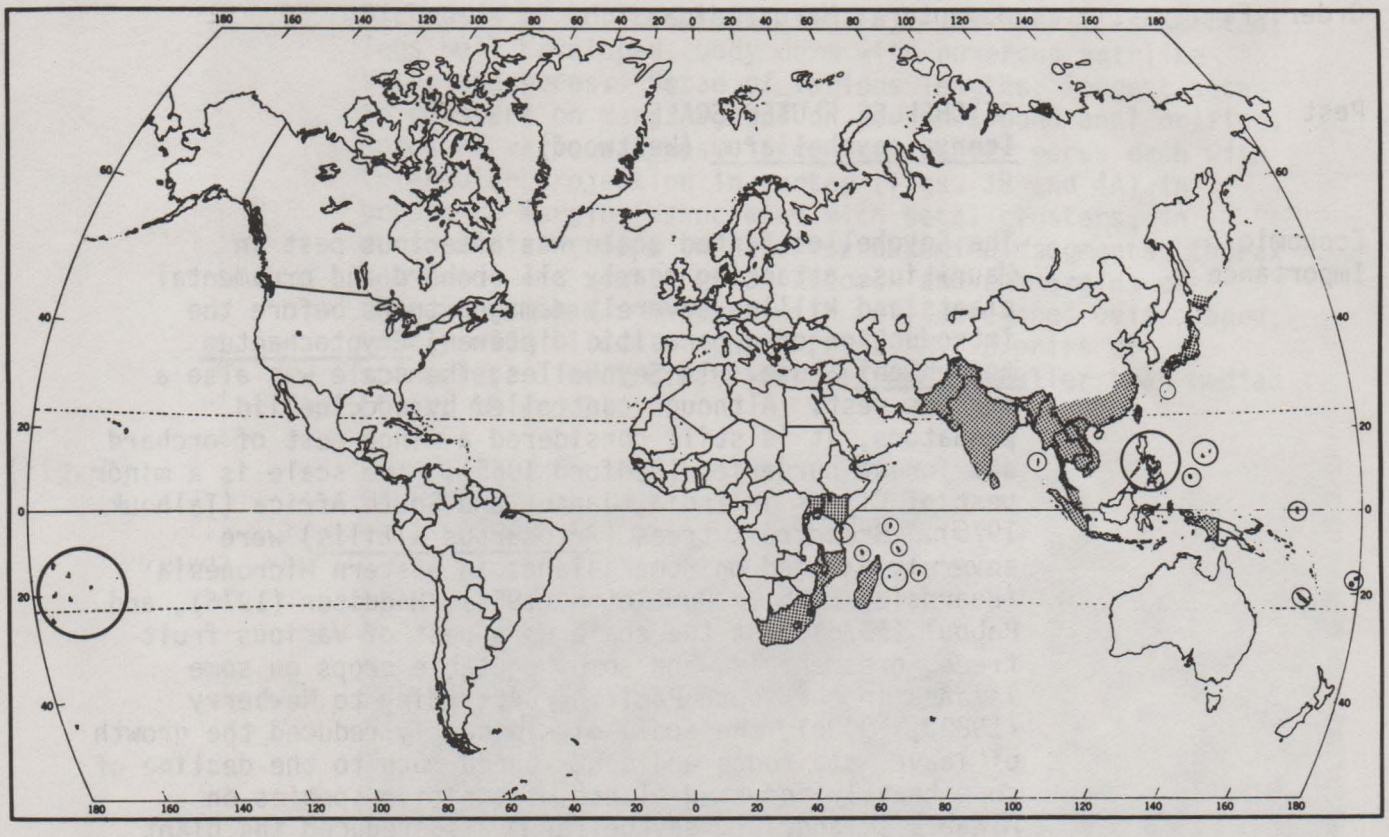
The Seychelles fluted scale was a serious pest in Mauritius, attacking nearly all orchard and ornamental plants and killing severely damaged trees before the introduction of a parasitic dipteran, Cryptochaetum monophlebi Skuse. In Seychelles, the scale was also a serious pest. Although controlled by coccinellid predators, it is still considered a minor pest of orchard and forest nurseries (Bedford 1965). The scale is a minor pest of Citrus in India, Japan, and South Africa (Talhouk 1975). Breadfruit trees (Artocarpus altilis) were severely damaged on some islands in Western Micronesia (Beardsley 1955). Dumbleton (1954), Maddison (1976), and Reboul (1976) list the scale as a pest of various fruit trees, ornamentals, and some vegetable crops on some islands in the South Pacific. According to Newberry (1980b, 1980c), the scale significantly reduced the growth of leaves and roots and contributed much to the decline of some heavily infested plants of a native species on Aldabra Island. I. seychellarum also reduced the plant growth and killed the apices of another species.

General Distribution

Africa: Agalega Islands, Aldabra Island, Egypt (Suez), Kenya, Madagascar, Malawi, Mauritius, Mozambique, Reunion Island, Rodrigues Island, Seychelles, South Africa, Uganda, and Zanzibar Island.

Asia: Andaman Islands, Burma, China (South China, Canton, Foochow), Hong Kong, India, Indochina, Indonesia, Japan, Malaysia, Pakistan, Philippines, Ryukyu (Amami Islands), Sri Lanka, Taiwan, and Thailand.

Oceania: American Samoa, Cook Islands, Fiji, New Caledonia, Niue Island, Palau Islands, Tahiti, Tonga, Ulithi Atoll, Western Samoa, and Yap Islands (Ali 1970, Almeida 1973, Beardsley 1966, Commonwealth Institute of Entomology 1955, Dumbleton 1954, Ezz and Samhan 1969, Maddison 1976, Rao 1951, and Wu 1935).



Icerya seychellarum map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Hosts

The Seychelles fluted scale is a polyphagous species that attacks a wide variety of ornamentals, fruit and forest trees, and vegetable crops. In Mauritius, this species is recorded from about 145 host plants (Mamet 1948). Some of the agricultural host plants include: Annona muricata (soursop), Annona squamosa (sweetsop), Artocarpus altilis (breadfruit), Cajanus cajan (pigeon pea), Capsicum frutescens (tabasco pepper), Carica papaya (papaya), Citrus aurantiifolia (lime), Citrus grandis (pummelo), Citrus limon (lemon), Citrus paradisi (grapefruit), Citrus sinensis (sweet orange), Cocos nucifera (coconut), Coffea arabica (coffee), Cucumis melo (melon), Cucumis sativus (cucumber), Ficus carica (common fig), Ipomoea batatas (sweet potato), Litchi chinensis (lychee), Lycopersicon esculentum (tomato), Malus sp. (apple), Mangifera indica (mango), Morus sp. (mulberry), Musa paradisiaca (banana), Olea europaea (olive), Passiflora edulis (passion fruit), Persea americana (avocado), Phoenix dactylifera (date palm), Prunus persica (peach), Psidium guajava (common

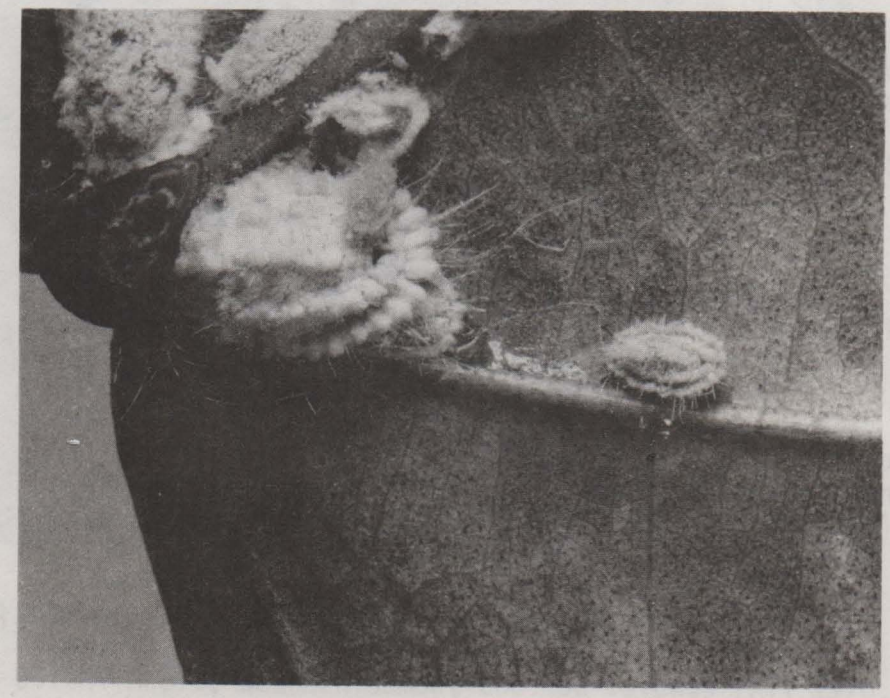
guava), Punica granatum (pomegranate), Pyrus communis (pear), Solanum melongena (eggplant), Solanum tuberosum (potato), Tamarindus indica (tamarind), and Vitis vinifera (wine grape) (Maddison 1979, Mamet 1948, and Reboul 1976).

Characters

Early immature stage covered with bright yellow or white wax. Bodies of intermediate stages yellow, covered with yellow wax that are lobed marginally and fringed with long, glassy, waxy filaments (Bedford 1965).

FEMALE ADULT - Body broadly oval, convex, about 5 mm long, 3 mm wide, orange red, covered with granular wax, either yellow or white tinged with yellow, and with many long glassy, waxy filaments; wax cover tufted in median longitudinal row on dorsum, in marginal row around body, and in row dorsal of marginal row on abdomen (fig. 1). Ovisac white, project from posterior end of body, covered dorsally by series of long cylindrical waxy processes (Rao 1951). Legs and antennae of all stages black.

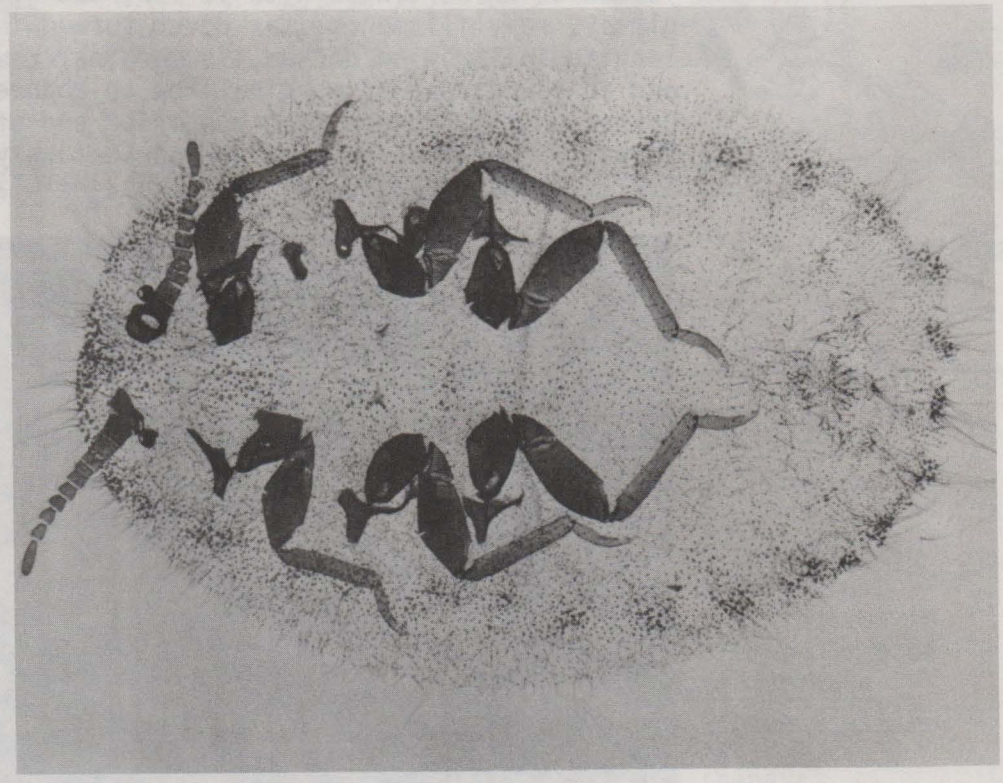
(Fig. 1)



Icerya seychellarum: Immatures and adult females on undersurface of leaf (Courtesy of Entomology Division, Department of Scientific and Industrial Research, Auckland, New Zealand)

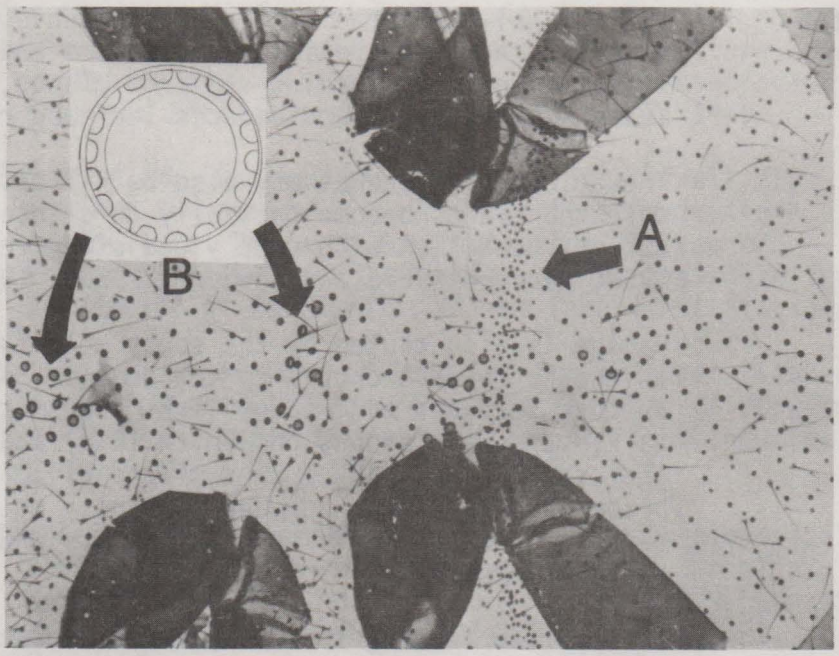
Diagnosis of adult female (fig. 2) - Antenna 11-segmented, legs well developed, body derm with numerous hairlike setae and pores. Setae of various lengths; longest setae in clusters on margins, and on dorsum around anal orifice. Pores of various types; large open center pores each with triangular projection in center (figs. 3B and 4A) in groups on margins associated with setal clusters, in dorso-medial groups on anterior abdominal segments, thorax and head, and scattered on abdomen and submargins of thorax and head. Abdomen with well developed ovisac band, mostly with bilocular pores (fig. 3A); 3 pairs of spiracles; 3 oval cicatrices, laterals smaller than median (figs. 4B and C).

(Fig. 2)



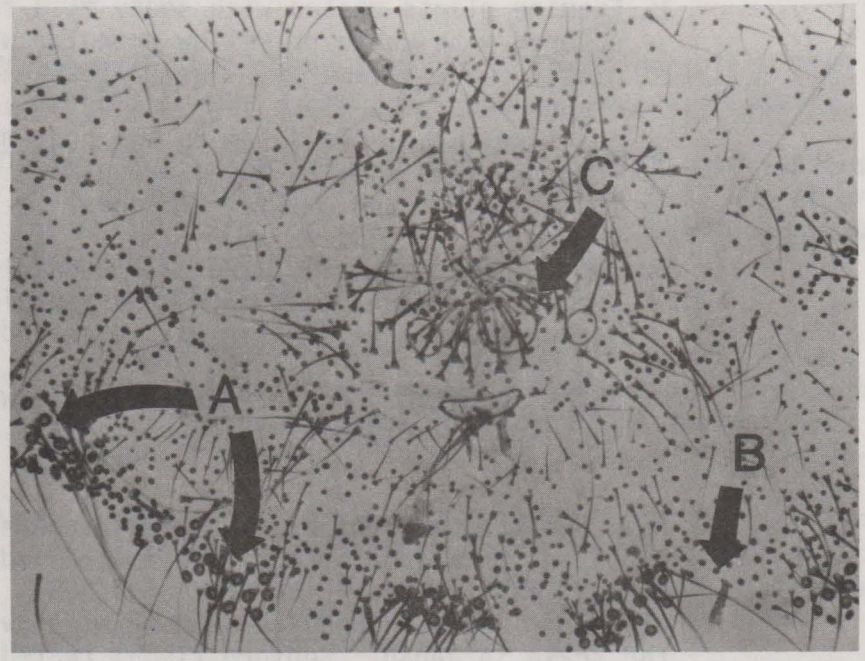
Icerya seychellarum: Slide mounted adult female

(Fig. 3)



Icerya seychellarum: Thorax and abdomen enlarged: (A) anterior part of ovisac band; (B) dorso-medial clusters of large open center pores

(Fig. 4)



Icerya seychellarum: Abdomen enlarged: (A) large open center pores; (B) abdominal spiracles; (C) cicatrices

Characteristic Damage

The Seychelles fluted scale infests leaves, twigs, smaller branches, and even petioles of flowers and fruits in heavy infestations. By sucking sap from plants, the scale lessens plant vigor and reduces leaf and root growth.

The apices of branches may also be killed. Heavily infested plants become partially defoliated, less vigorous and may be killed with crop yield often reduced (Beardsley 1955, Bedford 1965, and Newberry 1980b, 1980c).

Damage is also caused by the sooty mold fungi that develop on the honeydew secreted by the scale. Sooty mold fungi on leaf surfaces can reduce light transmission by as much as 25 percent (Teeders and Smith 1976) and thereby reduce photosynthesis. The upper surfaces of leaves and fruits become covered with honeydew and sooty mold fungi, thereby reducing the aesthetic value of plants and the market value of fruits.

This phloem feeding species prefers senescing leaves to green leaves, and removes water, carbohydrates, and nitrogen from the plants and secretes honeydew (Newberry 1980a, 1980b).

Detection Notes

1. Examine plants coated with sooty mold fungi for insects covered with white or yellow granular wax with long, glassy, waxy filaments. The bodies are yellow or orange red, with black legs and antennae and many hairlike setae; the setae on the body margins are long. Scales usually found along main veins of leaves, and on twigs, and smaller branches.

2. Collect specimens in 70 percent ethanol in a vial and submit for identification. Other species of Margarodidae have similar wax cover and coloration.

3. Mount specimens on slides and examine with a compound microscope for positive identification.

Natural Enemies

Cryptochaetum monophlebi Skuse (Cryptochaetidae), a Dipterous parasite, effectively controlled the Seychelles fluted scale in Mauritius (Bedford 1965). According to Clausen (1931) C. grandicorne Rondini heavily parasitized the scale in Japan. Bedford (1965) reared two specimens

of C. utilis van Bruggen in South Africa but states that Icerya seychellarum was not the normal host. The predators are mainly coccinellids. Rodolia cardinalis (Mulsant) was an effective control agent in Seychelles (Bedford 1965). Rodolia chermesina Mulsant and Exochomus laeviusculus Weise were effective predators in Mauritius when the ant, Technomyrmex detorquens Walker, was controlled (Moutia and Mamet 1946). Chilocorus nigritus L. was not a significant predator in Aldabra Island (Hill and Blackmore 1980) and Rodolia pumilus Weise is a suspected predator in Yap and Palau Islands (Beardsley 1955). Other coccinellids giving varying measure of control are R. obscura Weise in Malawi and South Africa (Bedford 1965); R. breviuscula Weise in India (Kapur 1949), and Pullus coccidivora Ayyar in Pakistan (Ahmad and Ghani 1972). Chrysopa flavostigma Esb.-Pet. (Chrysopidae) is another predator in Seychelles (Vesey-Fitzgerald 1941).

Biology

There are three immature instars. The adult female is viviparous, lays eggs in an ovisac, and is probably hermaphroditic. Males are rarely found (Newberry 1980b). In Japan, there is one generation per year. Mature females overwinter and lay eggs beginning in early June. The eggs hatch within a few hours after oviposition (Clausen 1931). According to Bedford (1965), one generation per year occurs in South Africa and most stages are present throughout the year. The immatures are most abundant during mid-summer and by the end of October, the scales are mature or maturing. On Aldabra Island the scale breeds continuously and completes a generation in 2 or 3 months. Although all stages are mobile, the scale is dispersed primarily in the crawler stage by wind (Hill and Newberry 1980).

Immatures and adult females are found mostly on the undersurfaces of the leaves, usually along the main veins. (as shown in fig. 1) (Bedford 1965).

Ants tend and protect the scales for honeydew. Hill and Blackmore (1980) report 4 species of ants tending the scale on Aldabra Island. In Seychelles and Mauritius, Technomyrmex detorquens Walker protects the scale from coccinellid predators (Dupont 1931, Moutia and Mamet 1946). Ant associations are also reported from Rodrigues Island (Mamet 1956) and Zanzibar Island (Way 1954).

Acknowledgments

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 22: GIANT AFRICAN SNAIL

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 402, Hyattsville, MD 20782

Order: Family — Stylommatophora: Achatinidae

Pest — GIANT AFRICAN SNAIL
Achatina fulica Bowdich

Economic Importance

This species is one of the most serious land snail pests known, reported to consume all growth stages of vegetables, cover crops, garden flowers, herbaceous ornamentals, and damaging many fruit and ornamental trees. In 1969, Florida estimated that an $11 million annual loss would be inflicted by this snail if it were unchecked.

A large infestation presents a nuisance problem with slime trails, excretions, and odors of decay when they die in large numbers. They also deface buildings by feeding on any material containing calcium, such as paint. Their dead bodies create health hazards by polluting wells and other water sources. Feeding on human, pet, and livestock excrement, may spread disease (U.S. Department of Agriculture 1970, Mead 1961).

During the past decade, *A. fulica* has been shown to transmit the rat lungworm, *Angiostrongylus cantonensis* (Chen), which causes eosinophilic meningoencephalitis in humans. This snail has also been shown to transmit *Aeromonas hydrophila* (Stainer), which causes several chronic, resistant disease conditions. Recently this bacteria has been found not only in a number of infrahuman, warmblooded species but in a surprising number of human pathologies. Some of these include acute bacteremia, osteomyelitis, septic arthritis, tonsillitis, and meningitis. *A. fulica* has also been implicated in transmitting the following plant pathogens: *Phytophthora palmivora* (Butl.) on commercial pepper, coconut, betel pepper, papaya, and vanda orchid; *Phytophthora colocasiae* Rac. on taro; *Phytophthora parasitica* Dast. on eggplant and tangerine.

On the positive side, the market for this snail species as food is expanding. This is leading to a reverse in thinking of this snail as a pest, especially in Taiwan. The snail is also useful in making fertilizer and chicken feed. Just beginning is the discovery that *A. fulica* and other giant snail species are valuable sources of biological compounds of unsuspected properties useful in clinical and experimental laboratories, particularly in Africa and

Asia. This scavenger performs an incidental benifit by consuming all sorts of unwanted offensive matter more rapidly than bacteria or fungi (Mead 1961 and 1979).

Hosts

This species is basically a scavenger, consuming all sorts of decaying organic matter: Excrement, dead and rotting plants and animals even soggy cardboard. This scavenger role complicates what is a "host" (Mead 1961).

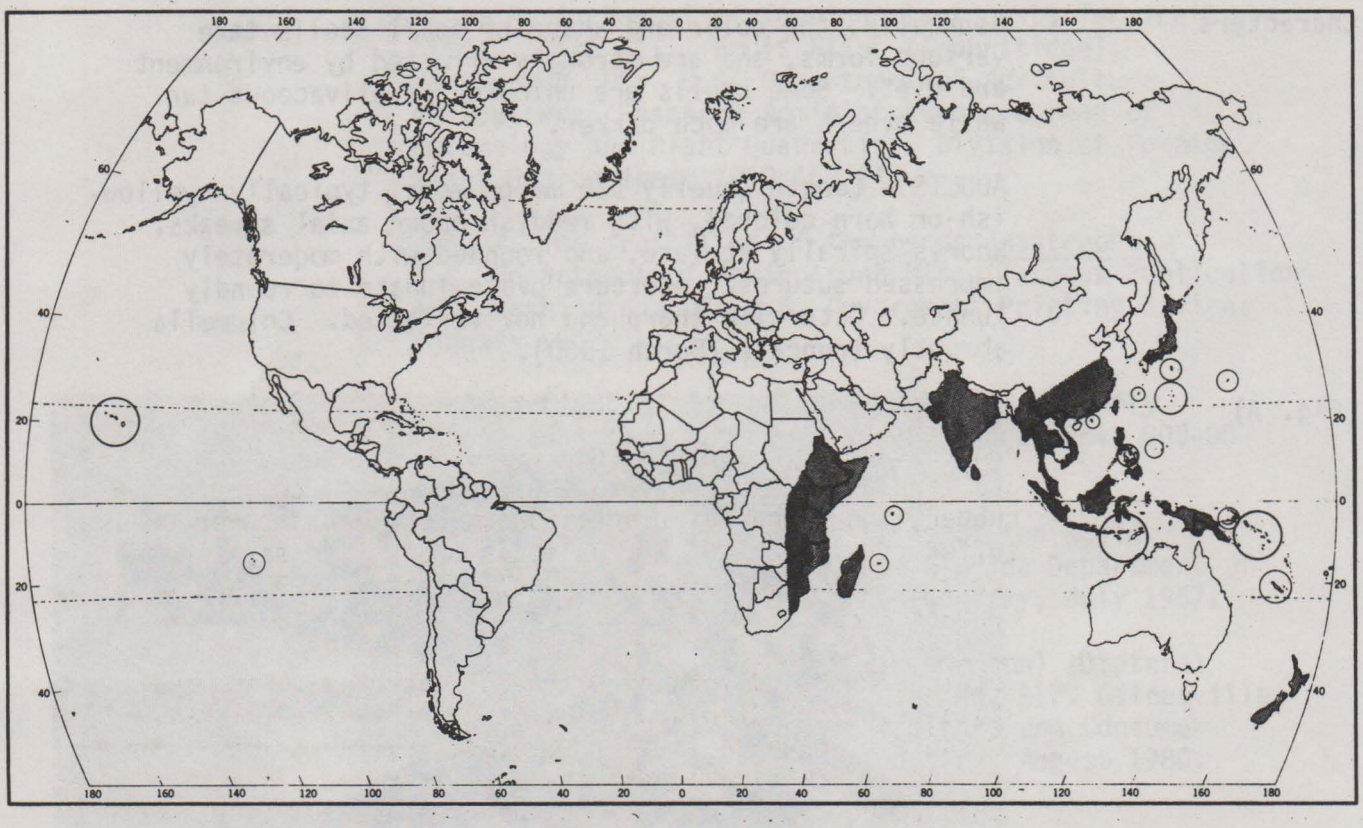
Although many plants of little economic value are eaten, the majority of the snail's hosts are cultivated plants. These include: All types of vegetable crops, such as lettuce, bean, pumpkin; cole crops such as cauliflower and cabbage; ornamentals such as marigold, portulaca, and zinnia. A. fulica also causes damage to coffee, rubber, and areca-nut plantations. Leguminous cover crops suffer considerably. Citrus fruit and citrus seedlings are also reported to be damaged (Srivastava 1973 and 1970, Denmark 1969).

Cuttings and seedlings of hosts not attacked in the mature state, e.g. breadfruit, casava, and treak, are completely consumed or have their bark removed. Overall, rubber is not damaged critically but the snails are a nuisance on trees being tapped because of their unique appetite for fresh rubber latex.

Giant African snails have been known to feed on fruits such as papaya and banana. All parts of the papaya plant are attacked, the fruit being one of the few actually primarily damaged to a great extent. The snails generally prefer rotting and therefore already damaged fruit.

Very little damage is done to all members of the grass family which includes sugarcane, corn, rice, and the small grains. This is universally true in all areas of the world. Other starchy crops such as taro and sweet potato are as immune, although the cassava suffers some damage and the yam is seriously attacked. Coconuts, pineapple, pandanus, coffee, and tea are also little damaged.

Indirect damage can be caused even to plants not eaten, such as breakdown due to the weight of excessive numbers of snails. An ironic twist is supplied by the land used for tea growing being rendered unfit due to attempts to get rid of the snails by collecting and burying them. The shells make the soil too alkaline for the acid-loving tea plants to grow (Mead 1961 and 1979).



Achatina fulica map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

General Distribution

The giant African snail is native to eastern Africa. In 1936 it became established on the island of Hawaii and has since spread to every island. An infestation discovered in Florida in 1969 has been eradicated. It has also been introduced into Southeast Asia, Bismarck Archipelago, Bonin Islands, Borneo, Caroline Islands, Southeast China, Guam, Hong Kong, India, Indonesia, Japan, Malaysia, Maldive Islands, Mariana Islands, Mauritius, New Britian, New Caledonia, New Guinea, New Ireland, New Zealand, Okinawa, Papau Islands, Philippines, Reunion, Ryukyu Islands, Sarawak, Seychelles, Sri Lanka, Tahiti, Taiwan, Thailand, and Vietnam (Denmark 1969, Burch 1960, U.S. Department of Agriculture 1970, Mead 1961).

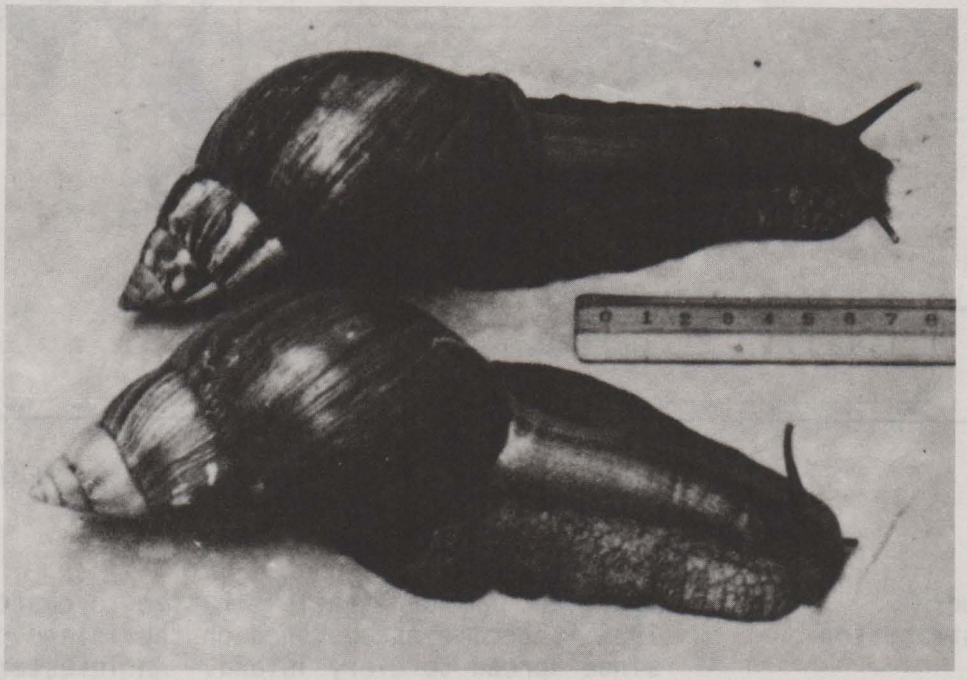
Specimens have been intercepted approximately 96 times from 1971 through 1981 at various U.S. ports of entry (U.S. Department of Agriculture 1981).

Characters

Generally, the color and shape of snail shells take various forms, and are strongly affected by environment and diet. Some shells are unicolorous olivaceous tan while others are much darker.

ADULTS - Length usually 125 mm or more, typically yellowish or horn-colored, with reddish brown axial streaks. Whorls spirally striate, and rounded with moderately impressed sutures. Aperture ovate-lunate to roundly lunate. Outer lip sharp and not reflected. Columella abruptly truncate (Burch 1960).

(Fig. A)



A. A. fulica adult

EGGS - Elyptical, about 4 mm by 5 mm in diameter, usually pale yellow, laid in clutches of 100-400.

IMMATURES - Length 4 mm, and increase 10 mm per month for first 4 months. Coloration similar to adults (Denmark 1969).

Characteristic Damage

Snails of all stages feed on the stems and foliage of plants. Infestations weaken plants and delay growth, often causing death. This pest has also stripped some tropical vegetable gardens of leaves, flowers, and tender

pieces of bark (Nair and Sadanandan 1974). Cover crops are prevented from producing green manure, shade, soil retention, and nitrogen fixation. It is believed that the greatest damage is found in new infestation sites or at the crest of expanding populations (Mead 1961 and 1979).

Detection Notes

1. Survey any time of the year, especially after dark in moist and sheltered places. Surveying is ideal in warm, wet weather.

2. Check plant material for extensive rasping signs, defoliation, slime trails, or ribbonlike excrement.

3. Collect and submit snails completely submerged in 70% alcohol. Empty shells may be shipped dry (California Department of Food and Agriculture 1971).

Biology

Although its average life span is about 3 years, giant African snail has been reported to live 6 years. They are hermaphroditic but cross-fertilization apparently is required. The number of matings required for full egg production potential is unknown. Under test conditions, isolated individuals can lay viable eggs for 382 days after mating. Egg laying begins at 5-6 months with individuals producing 300+ eggs in 1 clutch per year. Under optimum conditions, 4 clutches of 150 eggs can be laid each year. Eggs are deposited in cool, moist soil and under objects on the ground. After the eggs hatch (11-day incubation period in the tropics), the juveniles eat the egg shell before seeking other food.

Although this species is normally nocturnal, it may become active at twilight, when the day is overcast and the soil is moist and warm. The snail is extremely sensitive to conditions of high evaporation rates. It becomes inactive and begins estivating within 24 hours under a slight moisture stress. Snails have also been observed to enter estivation without a moisture stress. Because of this it is believed that estivation may be cyclic. Estivation can occur as snails cling to solid objects, aiding in spread to new areas by artificial means.

During unfavorable periods, the snail buries itself 10-15 cm in soft soil and may become inactive up to a year, losing 60% of its weight. Physiological changes in blood and certain organs occur before and during the period of inactivity. The ability to withstand trauma and an extensive shell loss indicates a general physical hardiness.

Scientific literature on the physiology of A. fulica is scarce. Estivation and hibernation are confusing and can be distinguished only by trained malacologists.

Behavior, size, and shape of the snail vary, permitting rapid adaptation to new environments. These variations could allow adaptations to colder and drier climates, and also a range extension farther north than is presently known. The exact ecological range is unknown; however, it can probably be predicted from combinations of temperature (minimum of -1.1°C), moisture (near subtropical rainfall), and available lime (soil origin and a pH of 7.0-8.0).

This species requires high levels of lime to prosper, due to its rapid growth rate and large size. There is a high positive correlation between available lime in the soil and the abundance of this snail. However, the lack of enough soil lime does not form a complete barrier. Abundant populations have been found in tea-growing areas where the typical soil pH is 4.5, and calcium carbonate could not possibly last long, especially in the presence of abundant moisture. Giant African snail can get enough lime from scavaging on fallen leaves because plants are able to extract the bound lime from the soil and concentrate it in the leaves.

Temperature and moisture are the most limiting factors. These factors should predict the northern limits of its ecological range with acceptable precision. This species is well adapted to tropical and subtropical climates and is abundant as far north as 30° latitude. In the Western Hemisphere, survival and establishment are likely in the area bordering the Gulf of Mexico (from Florida to Texas), in the irrigated desert areas of southern California, and also many parts of Mexico and Central America (U.S. Department of Agriculture 1970, Mead 1961).

Controls

The general methods for controlling land mollusks include: Mechanical crushing, grinding, handpicking, and trapping; physical manipulation of moisture and temperature; chemical attractants, baits, repellents, and toxicants; agronomic practices; and biological introduction of diseases, parasites, and predators. Mollusk control usually involves repeated broadcasting of poisoned baits. Biological control has been widely used because manpower and technology to develop and practice other methods are not available or justified (U.S. Department of Agriculture 1970, Mead 1961).

To date, some of the most important predators of the giant African snail include: Insects, 5 species of Lampyridae (Coleoptera), primarily Lamprophorus tenebrosus (Walker); crabs, primarily hermit crab (Oenobita perlatus) (Milne Edward), and rubber or coconut crab (Birgus latro (L.)); and snails, Edentulina affinis (C. R. Boettger), Gonaxis quadrilateralis (Preston), Gonaxis kibweziensis (E. A. Smith), and Euglandina rosea (Ferussac), which is native to the Gulf States. Efforts to use predators and parasites for control on the Hawaiian Islands have not been very successful (Mead 1961, U.S. Department of Agriculture 1970). Furthermore, the introduction of snail predators is believed to have resulted in unwanted predation on endemic tree snails (Achatinella spp.) (Bender 1981).

An endemic disease syndrome of giant African snail will become epidemic under population stress. This corresponds with the earlier observed rise and fall of populations following introduction into new territory. The snails normally build up to extremely high densities, decline within several years, and become incidental. Presently, the cause and means of using this disease syndrome for control is under investigation. Authorities believe that ants, birds, centipedes, cestodes, flies, fungi, mammals, millipedes, mites, nematodes, protozoans, and reptiles have growing potential and need more research (Mead 1979).

A striking reduction of giant African snail populations has resulted from the accidental introduction of a flatworm (Geoplana sp.) into Guam. This predator, first observed in 1978, is fast growing and has spread over the entire island. This flatworm has also been reported to have been established on Saipan in the same manner. Members of this genus have been observed devouring snails in Hawaii since 1907 and are probably vectors of the above-mentioned disease syndrome, but the use of these worms as control agents has never been fully explored because of general doubt that they would be effective, and might have some disadvantages. Geoplana spp. have been shown to also carry the eosinophilic meningoencephalitis (mentioned above) to humans (Muniappan 1981, Mead 1963).

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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 23: WHITE GARDEN SNAIL

Prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff, Federal Building Room 626, Hyattsville, MD 20782

Class: Gastropoda

Order: Family: Stylommatophora: Helicidae

Pest: WHITE GARDEN SNAIL
Theba pisana (Muller)

Economic Importance

Theba pisana is well adapted as an agricultural pest to arid regions. In Israel, this species causes severe damage to ornamental plants, vegetables, and citrus trees along the Mediterranean coastal plain (Avidov and Harpaz 1969).

This species is of great concern to agriculture because of its high reproductive capacity. Crops and gardens suffer tremendous losses from large populations of this snail.

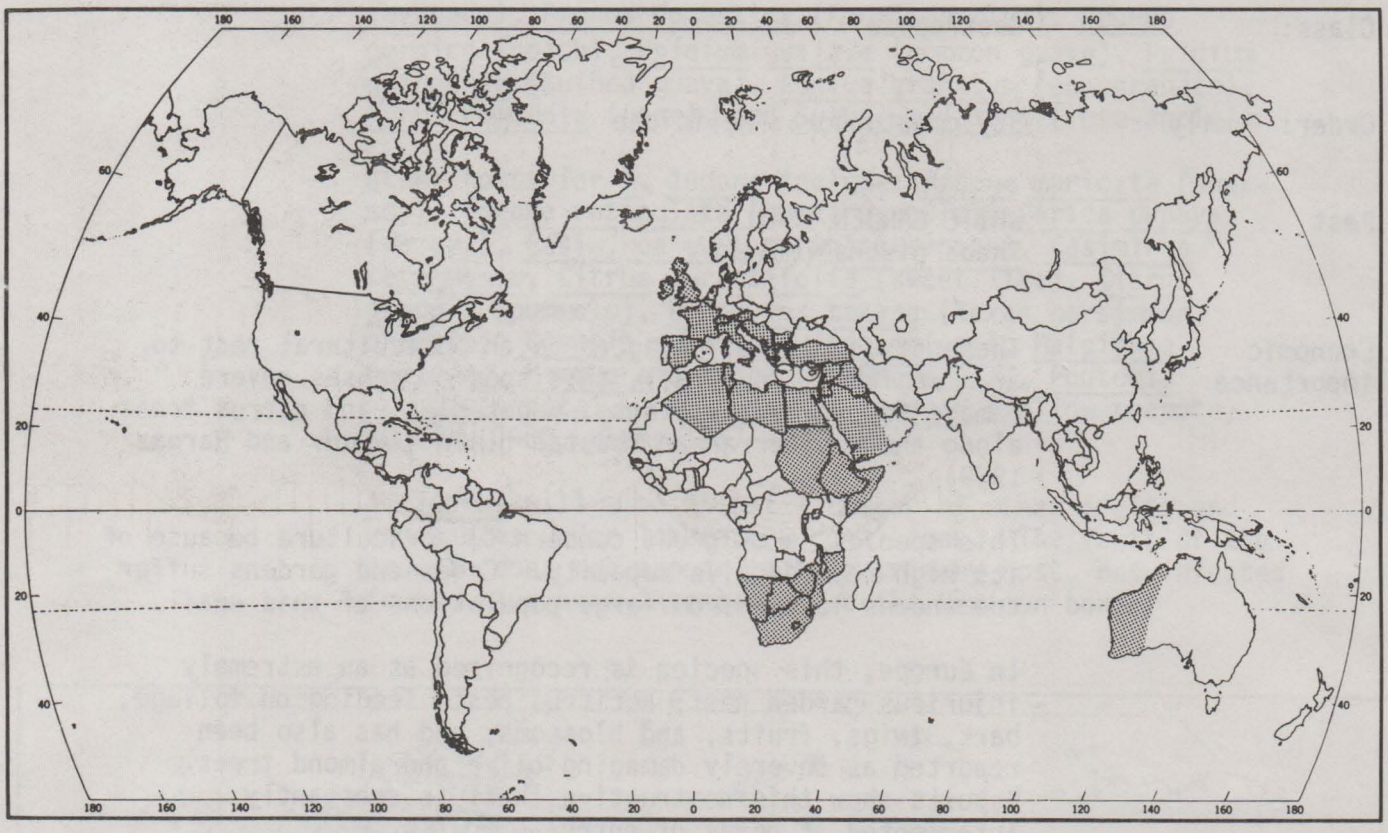
In Europe, this species is recognized as an extremely injurious garden pest; a citrus pest, feeding on foliage, bark, twigs, fruits, and blossoms; and has also been reported as severely damaging olive and almond trees. Reports show this destructive snail is constantly intercepted at ports of entry.

General Distribution

This species, a native of Sicily, is distributed in all the countries of the Mediterranean area (Albania, Algeria, Cyprus, Egypt, Ethiopia, France, Greece, Iraq, Israel, Italy, Jordan, Lebanon, Libya, Saudi Arabia, Spain, Sudan, Syria, Tunisia, Turkey, Yemen, Yugoslavia), Somalia, Switzerland, and United Kingdom (Western England and Wales). It has also been introduced into Western Australia, and the southern area of Africa (Botswana, Mozambique, Namibia, South Africa, Zimbabwe). Several infestations of the white garden snail have been eradicated from California. The first detection in California was made at La Jolla in 1918.

Hosts

This pest has been known to feed on the living foliage of many garden plants and weeds, also as a scavenger on organic matter. It is a particular problem of Citrus spp. (Paddock 1978).



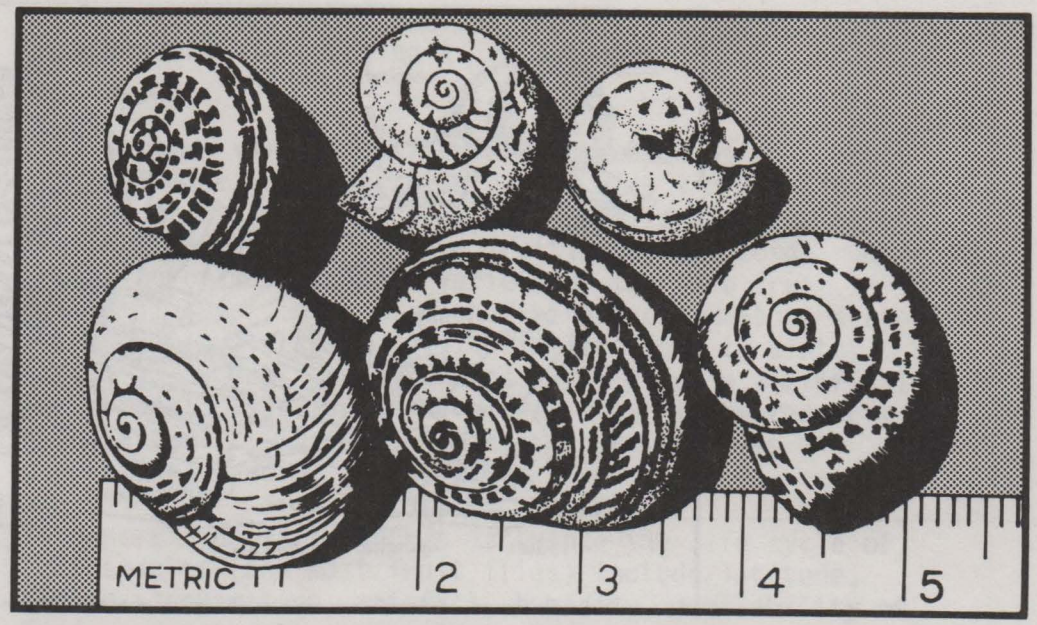
Theba pisana map prepared by USDA, APHIS, PPQ, Biological Assessment Support Staff

Characters

ADULTS - Shell ivory yellow, nonglossy surface. Distinct band pattern with unequal brown bands represented by dots (fig. A). Adult shell opaque, width about 22 mm, height 15 mm, 4.5 whorls. Fine spiral striae (raised or impressed lines) sculpture the whorls. There is a wide variation from the type described above, ranging from plain white shells with no stripes, to those with as many as 14 lineal stripes (see fig. A).

At La Jolla, in a collection of 1,093 specimens, 6 1/2 percent were plain white or buff, 10 percent were strongly striped, and 83 1/2 percent ranged from the faintest marking to those with medium strong striping. Size of the shells of various ages ranged from 3-19 mm and the largest specimens found at La Jolla measured 24 cm across the widest diameter. The shell has a minute opening at the base. The aperture is shaped like a half moon. The lip is sharp, often ringed inside with a callus or thickening (Basinger 1927, Dees 1970).

(Fig. A)



Shells of Theba pisana showing variation in pattern (drawing after Paddock 1978).

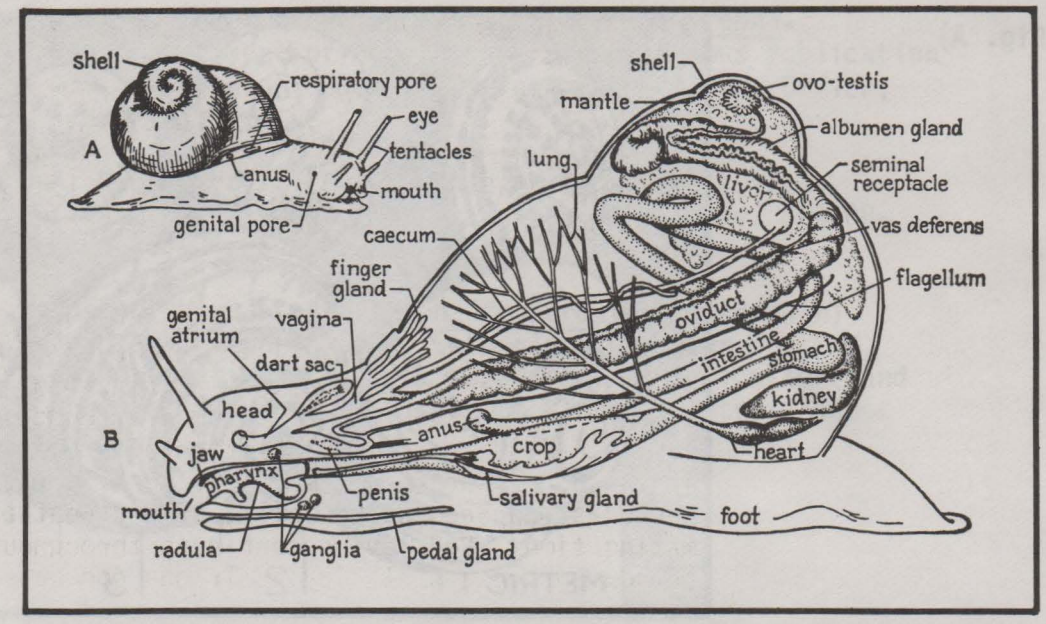
Body color varies from light cream to dark gray, length 5 cm or more when fully matured. Anterior end with two pairs of tentacles which serve as the sight and smell organs. The foot on the underside of the body secretes mucus and provides locomotion. The mouth has fleshy lips, backed by a hard chitinous plate which has a sharp-toothed edge used as a rasp or scraper during feeding and the radula which guides food into the digestive tract. See fig. B for typical helicid external features and internal structures.

EGGS - Similar to typical snail eggs. White, turgid, 3-4 mm. Eggs deposited several cm into soil in a gelatinous mass from 1-4 days after fertilization, following the first fall rains.

Characteristic Damage

Food is held by the jaw and rasped off by movements of the radula. Garden and field plants and even trees are severely damaged by the consumption of the green vegetation and other parts. This snail feeds on citrus leaves and tender bark, especially of young trees.

(Fig. B)



Typical external features (A) and internal structures (B) of Helicidae. From General Zoology. 2d ed. by Storer, T. I. Copyright © 1951 McGraw-Hill. Used by permission of McGraw-Hill Book Company.

Detection Notes

1. White to ivory-yellow snails are suspect. Submit shells for identification.

2. Look for clusters of suspect snails on sides of buildings, fences, rocks, etc. Submit for identification.

3. Look for active snails in moist weather or in areas subjected to sprinkling practices.

4. Look for epiphragms (the parchmentlike substitutes for opercula, see biology) remaining where snails have aestivated and then moved on with return of moist weather.

5. Since some color variants of the European brown snail can resemble the white garden snail, suspect subjects should be submitted for determination.

6. Preservation of snail specimens can be done by extracting the soft parts and keeping the shell dry, since identification is ordinarily done by the shells alone. This extraction is done by boiling for up to 5 minutes in fresh water, depending on size, to facilitate removal.

If the soft parts of the snails are to be preserved, the method described for preserving slugs works well. Specimens are drowned in a 1 percent solution of sugar, especially sorbitol, with chloral hydrate or a few crystals of thymol as an anesthetic. Permanent preservation is in 75 percent ethyl alcohol, never in a formaldehyde solution which destroys the shells (Paddock 1978, Hanna 1966).

Biology

Theba pisana is hermaphroditic, but mutual fertilization is necessary for reproduction. Mating begins in the fall when the first rains come, but may also be induced by artificial watering. Oviposition after mating can occur in 1-4 days, but this time might greatly extend, e.g. 3 weeks as happened at La Jolla, if dry weather occurs after mating time. Egg laying continues throughout the rainy season but each snail lays only one egg mass per season.

The snail finds a suitable place where the soil is moist and begins to dig. The shell is upright, aperture to the ground and only the tip of the foot sticking out. A round hole is dug down to about 40 mm and the lower half is enlarged to form a cavity for the egg mass. The dirt, dug loose by the lips and jaw, is pushed out by the under surface of the foot in an endless ribbonlike stream. A little conical pile is formed at the tip of the foot which is sticking out on one side of the shell. The snail does not withdraw from the hole until the entire process of digging the hole and laying eggs is finished.

The genital aperture is located at the anterior end near the right ocular tentacle (see fig. B). The eggs are laid singly, but as they emerge from the genital aperture they adhere to each other, forming a single mass that looks much like a white blackberry. When all of the eggs are laid, the snail plugs the top of the hole with a mixture of mucus and particles of dirt, then crawls away. The closing of the hole is very inconspicuous and the only evidence that remains is a pile of earth about 13 mm high and 26 mm in diameter. The number of eggs varies greatly; at La Jolla 52-226 eggs in each nest averaged a little over 120.

The time of incubation varies according to moisture and temperature. This period was 12-16 days in Italy and 20-30 days at La Jolla in April 1919 and 20-21 days in December 1922. The shell of the newly hatched T. pisana is about 2 mm in diameter and has one and one-half whorls.

Feeding soon starts on tender plants nearby, and the young snail increases its shell size. At La Jolla, snails ranged 5-11 mm 14 weeks after hatching. Shell growth is very rapid during wet weather and the shells cannot be picked up without crushing them. Growth occurs almost entirely during periods of moist or wet weather. Activity is not entirely dependent on rain as there is some movement during foggy weather when there is a heavy dew.

The young do not wander far for at least several months. The older individuals wander farthest, only these are found some distance from the general infestation. Their habit of sticking on a great many different kinds of surfaces gives them an aid in dispersion, through the transportation of plants and other articles.

Because there was, as is usual, a season of more or less continuous favorable weather for several months during the winter at La Jolla, a uniform shell growth of some extent was made, but for the rest of the year only occasional short periods for growth occurred, the intervening periods being spent in aestivation. This resulted in a narrow, rough band alternating with the broader uniform band of the winter's growth. These growth rings were very plain on some shells. Some showed as high as 4 winter seasons' growth and those of 2 or 3 seasons were common.

The food of T. pisana consists mostly of foliage but the species also feeds on other things. The pulp from weathered wood or paper is often eaten. Soil is commonly taken into the digestive tract.

One of T. pisana's most noticeable habits is climbing up on objects such as sticks, trees, grass, shrubs, and buildings in great masses and sealing itself fast during the summer season. On the ground snails are always under plants, stones, or boards, never on bare, exposed ground. In the rainy season they are scattered on the plants upon which they are feeding.

There is no operculum for closing the aperature of the shell as in some species, but an epiphragm is constructed over the opening of the shell. The epiphragm is like heavy parchment and prevents the drying up of the snail while it is inactive. The seal is pushed off and discarded when it renews activity.

Even when tightly sealed up, snails respond readily to stimuli. If several are placed in a vessel or held in the hand, they soon push off the epiphragms and begin crawling about. Many crawl about and feed during a little shower or even fog and dew in the middle of summer.

Natural Enemies

Natural enemies cited in Europe include hedgehogs, crows, magpies, owls, carabids, lampyrids, and a carnivorous species of snail that feeds on the young of Theba pisana (Basinger 1927).

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